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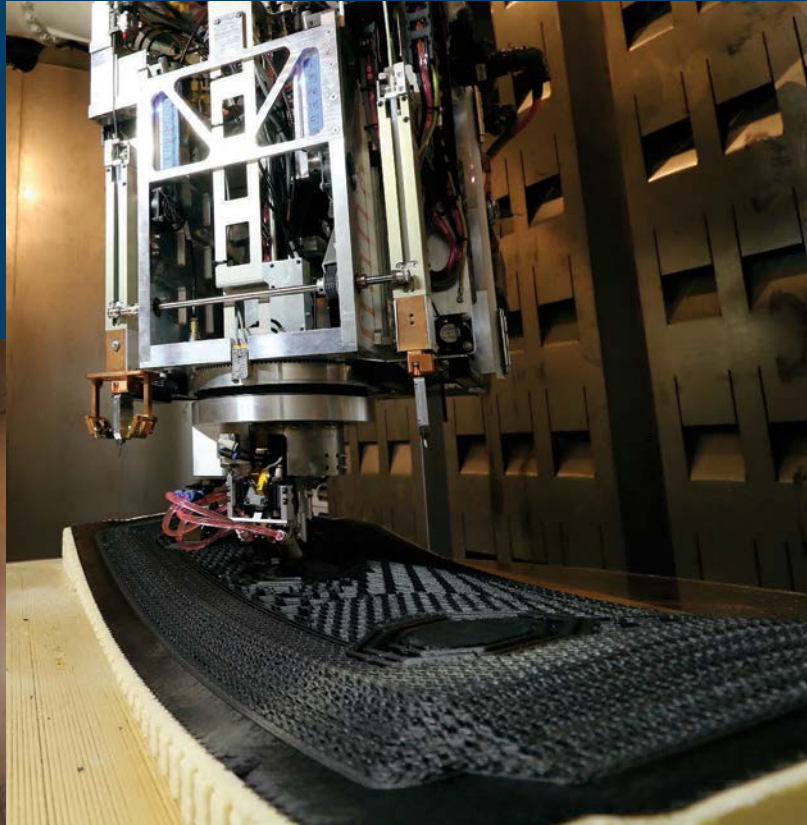
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NASA Administrator Jim Bridenstine, foreground, overseeing his first human spaceflight, snares a selfie with Demo-2 astronauts Robert Behnken, left, and Douglas Hurley inside the Kennedy Space Center Astronaut Crew Quarters —used for every NASA human spaceflight mission since the 1960s. Credit: Kim Shiflett/NASA

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ON THE COVER

After 18 years and 92 launches, SpaceX founder, CEO and Chief Engineer Elon Musk celebrated his company's achievement of becoming the first private entity to fly people to orbit. Space Editor Irene Klotz's report begins on page 22. NASASpaceFlight.com photo by Brady Kenninston.

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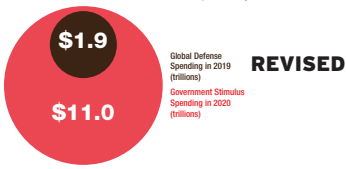
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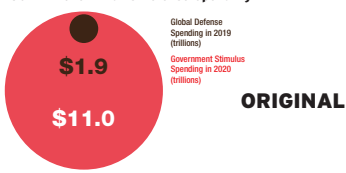
OUT OF PROPORTION

The “COVID Relief Dwarfs Defense Spending” graph in “First Take” on page 8 of the *May 18-31* issue is highly misleading. The reader of such a graphic would naturally assume that the areas of the circles are proportional to the numbers they represent. It seems, however, that the designer of the graphic made the diameters of

COVID Relief Dwarfs Defense Spending



COVID Relief Dwarfs Defense Spending



the circles proportional to the represented numbers rather than the areas, causing the areas to be proportional to the square of the numbers. The large circle is thus over 30 times the area of the small circle, when it should be only about 5.8 times the area. Many readers will glance at the graph and come away with a very inaccurate impression.

Tim Coleman, Lynchburg, Virginia

‘STOLPORT’ STALL

I read with interest Brad Gale’s comments in “The Short of It” (*May 18-31*, p. 5), as I was American Airlines’ manager of airport planning at its former New York headquarters and had the job of developing the “STOLPort” runway (and supporting passenger facilities) that was simulated in flight operations as described by Brad. Our objectives were to develop an operation that would be superior in travel time to Eastern’s Air Shuttle and American’s frequent services to Dulles Airport and Boston’s Logan Airport.

Early on, we concluded approaches and departures had to be over water, or at least no further in than the West Side Highway, to avoid dense commercial and residential development. We also concluded we would have to be close enough to the Midtown Tunnel to minimize crosstown travel time. We

selected a point on the Hudson, west of Madison Square Garden, where the shoreline made a bend slightly southeastward, and someone came up with the idea of making it a floating facility, runway and all, using the “mothballed” fleet of Liberty Ships. Basically, we designed an aircraft carrier, tethered to shore and floating vertically with the tide.

Alas, the “Chelsea Against the STOLport Committee” representing many West Side residents of the city protested. The pressure on Mayor John Lindsay was too much, and the city withdrew its support for the two-year Northeast Corridor demonstration grant we were seeking.

Fifty years later, we seem to think electric propulsion of quiet, autonomous air taxi aircraft will gain public acceptance on the ground. However, air traffic control issues notwithstanding, let us not ever disregard the possibility of public opposition to unconstrained, frequent, low-level overflight of residential land areas.

George P. Vittas, Bedford, Texas

BIG ISLAND

“Adapt or die” is the applicable adage for the airline industry today. People don’t want to get on airliners because they are afraid they will get the novel coronavirus by sharing a confined space with other passengers, some of whom may have asymptomatic COVID-19.

What the airlines need to do is come up with the number and combination of existing COVID-19 tests that work to get a 99.9% confidence level. Then they need to test it. Here’s how: There are no new COVID-19 cases on the big island of Hawaii. Airlines should fly to there for two weeks and regularly test everyone on the island to confirm that no new cases arise when they fly in tourists. This would be the acid test.

If the airlines can demonstrate successful COVID-19 testing, they are back in business. Adapt to testing; don’t die.

William Thayer, San Diego

DISPUTED CLAIM

I always enjoy Graham Warwick’s insightful reporting. Surprisingly, I think I caught him in a minor misstatement in his “Short Story” (*May 18-31*, p. 48).

In discussing the NASA Quiet Short-Haul Research Aircraft (QSRA), he notes that “it contributed to the design of the Boeing C-17.” I suspect that he was actually thinking about the Boeing YC-14 that shared the upper-surface blown-flap design demonstrated by the QSRA. The C-17 traces its lineage to the then-McDonnell Douglas YC-15 with externally blown flaps.



MIT

Chris Mayrand, Beavercreek, Ohio

Editor’s note: Here is how NASA claims it contributed to the C-17: nasa.gov/centers/langley/news/factsheets/C-17.html

ONLINE, in response to “Is Super-STOL A Viable Alternative To Electric VTOL?” (*May 18-31*, p. 48), MARKPAGE writes:

Very informative article. Really excellent. Years ago Douglas studied a Super-STOL concept with a swept wing that was rotated perhaps 20 deg. for takeoff and landing to limit the takeoff rotation problem, and control was provided by elevons and rudders on a C-winglet to keep the controls in the propwash with good lever arm. No other tails were needed.

And in response to “Autonomous Technology Prompts Ethical Calling for German FCAS” (*June 1-14*, p. 32), KPAR writes:

“Fighting at machine speed is accompanied by a real risk of escalation. So it is prudent that we keep humans as circuit breakers,” Frank Sauer So true. I’m glad that Germany is keeping the focus on the ethics of automating defense tactics. Something that all Americans, liberal or conservative, need to consider. This problem transcends politics.

Address letters to the Editor-in-Chief, *Aviation Week & Space Technology*, 2121 K Street, NW, Suite 210, Washington, DC, 20037 or send via email to: awstletters@aviationweek.com Letters may be edited for length and clarity; a verifiable address and daytime telephone number are required.



Jeff Lewis has been promoted to *Raytheon UK* CEO and managing director from chief operating officer. Lewis has worked for Babcock Marine, the Weir Group and Balfour Beatty within the global defense sector. He succeeds **Richard Daniel**, who will remain as an advisor.

Thommen Aircraft Equipment of Switzerland has hired **Daniel Grosch** as CEO. He held leadership positions at MSI Defence Systems, Arktis Radiation Detectors, Bruhn NewTech and L-3 Communications.

Bristow Group and Era Group, merging as *Bristow*, have announced a new leadership team drawn from both entities: **Chris Bradshaw**, president and CEO; **David Stepanek**, executive vice president and chief operating officer; **Alan Corbett**, senior vice president for Europe, Africa, the Middle East, Asia and Australia, and UK search and rescue; **Stuart Stavley**, senior vice president for global fleet management; **Samantha Willenbacher**, senior vice president and chief commercial officer; **Jennifer Whalen**, senior vice president and chief financial officer; **Crystal Gordon**, senior vice president and general counsel; **Mary Wersebe**, senior vice president and chief administrative officer; and **James Stottlemeyer**, vice president of health, safety and environment.



Lockheed Martin has promoted **Yvonne Hodge** to senior vice president of enterprise business transformation

from space sector vice president of business innovation transformation and enterprise excellence.

Dave Andrew has been promoted to *ASL Group* CEO from CEO for Africa, Asia and the leasing sector, with responsibility for all fleet and leasing operations. Andrew succeeds **Hugh Flynn**, who will retire as CEO in July but will serve as a nonexecutive director of ASL's Aviation Holdings and as nonexecutive chairman of ASL's subsidiary airlines in Ireland, Belgium, France and Hungary.

K. Christopher Farkas has been promoted to *Curtiss-Wright* vice presi-

dent and chief financial officer. He was vice president of finance and corporate controller. He succeeds Glenn E. Tynan, who will assist the transition until his retirement this fall.

The International Aircraft Dealers Association has promoted **Erika Ingle** to director of operations. Ingle will be responsible for the day-to-day operation of the organization and its initiatives.



Ball Aerospace has appointed **Deirdre M. Walsh** vice president of Washington operations. Walsh, who will oversee government rela-

tions, is former chief operating officer of the Office of the Director of National Intelligence.

The Center for Strategic and Budgetary Assessments has named **Chris Bassler** as a senior fellow for research on joint aerospace capabilities, maritime operating concepts and U.S. military strategy. He was chief strategy officer for the F-35 Lightning II Joint Program Office and held several senior positions within the U.S.



Navy, also serving on NATO forums.

Paul Dampousse, vice president of Calspan business development, has been named to the *FAA's Commercial*

Space Transportation Advisory Committee. Dampousse will serve as the chair of the innovation and infrastructure working group.

MDA Corp. has hired U.S. Army Col. (ret.) and retired NASA astronaut **Tim Kopra** as vice president of robotics and space operations, responsible for the work of the robotics and space operations teams at MDA facilities in Brampton and Ottawa, Ontario; Saint-Hubert, Quebec; and Houston. Kopra was a partner and advisor at private equity firm Blue Bear Capital and before that was a NASA astronaut and vehicle integration test engineer.

Specialized manufacturing group *AlphaCoin* has promoted **Robert Brooks** to chief financial officer from vice president of finance for its Connecticut Coining Inc. subsidiary, and **Steven Maturo** to associate director of business development from plant manager for its Gasser & Sons subsidiary.

MTU Aero Engines' supervisory board has extended the contracts of two of its executive board members—**Peter Kameritsch**, chief financial and chief information officer, and **Lars Wagner**, chief operating officer. They are to serve through December 2025.

Robert O. Work has been elected board chairman of *Govini*, a data science company whose analytic platform is used by U.S. defense agencies. Work serves on the board of Raytheon Technologies and is a member of the Council on Foreign Relations and the International Institute for Strategic Studies. He was deputy secretary of defense in 2014-17.



Aero Precision Holdings has elected **Brad Morton** to its board. He also serves on the boards of Proponent and Noble Aerospace. He was Eaton Corp. Aerospace Group president.

Jeremy Turpin has been appointed to the *Space and Satellite Professionals International* board. As Isotropic Systems' co-founder and chief technology officer, Turpin heads high-throughput optical multibeam antenna design and development.

HONORS AND ELECTIONS

George E. Bye has been named to the Titan CEO program's inaugural *Titan 100*, which recognizes 100 Colorado executives for exceptional leadership, vision and passion. Bye is the founder of Bye Aerospace, a developer of innovative aircraft concepts. Titan CEO will confer the award during 2020. ☼



To submit information for the Who's Where column, send Word or attached text files (no PDFs) and photos to: whoswhere@aviationweek.com For additional information on companies and individuals listed in this column, please refer to the Aviation Week Intelligence Network at AviationWeek.com/awin For information on ordering, telephone U.S.: +1 (866) 857-0148 or +1 (515) 237-3682 outside the U.S.

FIRST TAKE

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AVIATIONWEEK.COM

SPACE

Four days after launching two astronauts to the International Space Station on May 30 on a test flight of its Crew Dragon commercial space taxi, SpaceX launched another Falcon 9 with 60 Starlink internet satellites, boosting the constellation to 480 spacecraft (page 22).

The U.S. arm of Japanese satellite-servicing startup Astroscale is expanding into geostationary orbit by acquiring the assets of Israeli docked life-extension company Effective Space Solutions.



Northrop Grumman will design the HALO habitation and logistics outpost for the lunar-orbiting Gateway under a \$187 million NASA contract. HALO and the Maxar Technologies power and propulsion element are scheduled to launch together in 2023.

COMMERCIAL AVIATION

The Hong Kong government will gain a minority stake in Cathay Pacific Airways as part of a HK\$39 billion (\$5 billion) bailout package that includes investment from the carrier's major shareholders.

The International Air Transport Association anticipates the global airline industry will return to profitability in 2022, after suffering a combined loss of close to \$100 billion for 2020-21 (page 14).

Daily flights in Europe rose above 6,000 on June 2 and stayed at that level for four days, showing a post-lockdown recovery in air traffic is getting underway, Eurocontrol said (page 20).

Carbon recycler LanzaTech has launched a sustainable aviation fuel spinoff, LanzaJet, with \$25 million in backing from Canadian and Japanese investors. The company plans to begin production in early 2022.

Leading the eVTOL Investment Race (U.S. \$ million)

Joby Aviation

\$721

Lilium

\$376

Volocopter

\$139

EHang

\$92

Overair **\$25**

Air taxi developer Lilium has secured an additional \$35 million from Tesla's biggest backer, Scotland-based investment management partnership Baillie Gifford. This values the startup at over \$1 billion, making it the second eVTOL unicorn after Joby Aviation.

Source: Aviation Week

GE Capital Aviation Services has delivered a Boeing 777-300ER to Israel Aerospace Industries in Tel Aviv as the prototype for a passenger-to-freighter conversion.

Several U.S. airlines are among 69 signatories of a letter supporting the stay of an order granting Ligado Networks access to mobile satellite service bands for a ground-based 5G network.

VIEW FROM EUROPE

Antivirus Injection for Europe

Responding to a brutal downturn in commercial aviation caused by COVID-19, the French and German governments have announced separate but comparable bailout plans for industry. They intend to save employees from layoffs and companies from bankruptcy. They also aim to cut aviation's environmental footprint.

As the leaders in European aerospace, they have taken measures to support export financing. France now allows aircraft buyers to suspend capital repayments for 12 months.

In France, a dedicated €1 billion (\$1.1 billion) fund, to which Airbus, Dassault, Safran and Thales will contribute €200 million, will help small and midsize enterprises (SME) in need of capital.

In Germany, the economic stabilization fund established for companies with urgent liquidity needs is now open to the aviation sector. In France, a second fund with €300 million in subsidies over three years will focus on SME digitalization and automation.

France will fund research with €1.5 billion over three years. In return, an Airbus A320 replacement is to be designed to enter into service in the early 2030s with 30% lower fuel burn.

In parallel, a hydrogen-powered, "zero CO₂" narrowbody is to be developed for introduction in 2033-35. A new regional aircraft, either hybrid electric or hydrogen-powered, should enter service in 2030.

In Germany, €1 billion has been allocated to a fund supporting research—not limited to aerospace—and €1 billion is earmarked for German airlines renewing their fleets with aircraft that are at least 30% more fuel efficient.

Mitsubishi Aircraft has halted SpaceJet flight testing and production, saying it must first meet cost targets then achieve type certification before manufacturing will be considered (page 21).

DEFENSE

A scramjet-powered missile developed under the DARPA/U.S. Air Force Hypersonic Air-breathing Weapon Concept program was destroyed in a recent test accident. The missile is believed to have inadvertently separated from the Boeing B-52 carrier aircraft during a captive-carry flight test.

The U.S. Air Force has extended initial operational testing of the Boeing KC-46A tanker for at least three years, until Boeing resolves issues with the boom operator's remote vision system.

The NATO Alliance Ground Surveillance Force conducted first flight of the RQ-4D Phoenix UAS on June 4 from Sigonella Air Base, Sicily. The system was delivered at the end of 2019.

Boeing flew the first of 72 Block III F/A-18F Super Hornets for the U.S. Navy on June 3 from St. Louis.

Aerospace Industrial Development Corp.'s AT-5 advanced jet trainer was photographed making its first flight on June 10 from Ching Chuan Kang Air Base, Taiwan.

Turkish Aerospace has revealed a mock-up of a second indigenous attack helicopter. The T-629 designation suggests it builds on the company's T-625 Gokbey utility helicopter.



PIPISTREL AIRCRAFT

GENERAL AVIATION

Pipistrel has received the first certifications for both an electric power unit and an all-electric aircraft, with its two-seat Velis Electro trainer receiving type certification from EASA.

South Korea plans to begin limited commercial urban air mobility service in Seoul in 2025 following a large-scale, public-private demonstration project that will run from 2022-24.

Kaman Aerospace plans to fly a commercial unmanned aircraft based on its K-Max heavy-lift helicopter in July or August. The optionally piloted aircraft is to be on the market in 2021 (page 11).



BETA TECHNOLOGIES

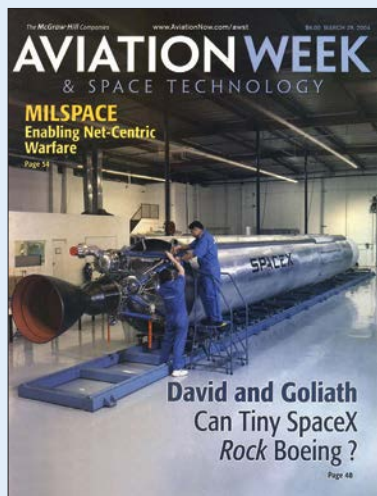
Startup Airflow has announced plans to develop a hybrid-electric short-takeoff-and-landing aircraft for aerial logistics, able to carry a 500-lb. payload 250 nm from a 300-ft. runway.

Beta Technologies and Joby Aviation are the first developers of urban air mobility vehicles to progress to the prototyping stage of the U.S. Air Force's Agility Prime program.

EHang has received approval from the Civil Aviation Administration of China to begin commercial operation of its EHang 216 electric air taxi for unmanned air logistics.

Bombardier Aviation plans to lay off 2,500 employees throughout 2020, primarily at its Canadian manufacturing facilities, as it adjusts to lower post-COVID-19 business-jet deliveries. 📉

16 YEARS AGO IN AVIATION WEEK



SpaceX's May 30 launch of two astronauts to the International Space Station on its Dragon capsule was a milestone for a company that was a 50-employee upstart when it was first featured on Aviation Week's cover on March 29, 2004. "David and Goliath: Can Tiny SpaceX Rock Boeing?" the magazine asked. SpaceX founder Elon Musk did not interpret that positively. "It's kind of a comical picture, to be frank, because I think the implied answer is 'no,'" he recalled last month.

But Craig Covault, the senior editor who wrote the five-page profile, begs to differ.

"Musk was just getting started, and some of my colleagues did not believe he was for real and worthy of significant coverage," says Covault, who is now retired. "I felt differently and proceeded to do a major cover story. I was impressed with Musk because he was laser-focused on commercial space and reducing costs versus Boeing/McDonnell Douglas and Lockheed Martin. He had also hired one of the best rocket propulsion engineers in the world, Tom Mueller, who was key to SpaceX's development of the relatively simple and highly reliable Merlin LOX/RP-1 engines."

In the article, respected physicist and engineer Michael Griffin explains in detail how SpaceX's model as a low-cost disruptor could be successful. Griffin later became NASA administrator and is now the Pentagon's chief technology officer. When Covault paid a return visit to SpaceX, framed copies of the cover were hanging in Musk's office and at the company's reception desk. "Musk was singularly focused on defeating the Boeing Delta IV Medium booster," he says. "And that is exactly what SpaceX did."

Subscribers can read our 2004 profile of SpaceX and every issue back to 1916 at: archive.aviationweek.com

UP FRONT

KEVIN MICHAELS

**COVID-19 IS THE BIGGEST CRISIS**

of the jetliner era, and attention is justifiably focused on air traffic, airline viability and production rates—with jetliner unit output likely to plummet 40-50% over the next two years. However, lurking beneath the surface are enormous supply chain risks that extend well beyond supplier viability and attrition. What are these risks?

Beginning with the OEMs, managing major rate reductions is an incredibly complex undertaking for supply chain organizations. Ordering and scheduling assumptions go out the window, and OEMs must negotiate with hundreds of suppliers—many already under financial duress thanks to the Boeing 737 MAX shutdown—to determine fiscal responsibility for work in process and inventory. Moreover, OEMs need to monitor the viability of thousands of suppliers several tiers down the chain to identify potential failure points. They need to avoid the crisis that hit the global automotive supply chain in 2011 when a single paint pigment supplier went offline following the Fukushima earthquake in Japan.

Communicating accurate and credible information to suppliers during a crisis is crucial. Lack of OEM supply chain function credibility will lead suppliers to develop their own production assumptions and capacity plans, which means they may not be ready when jetliner demand returns. Or they could overorder, weakening their financial position. OEM supply chain organizations are often caught between the company's desire to present an optimistic outlook to financial markets and reality. Transparency and frequent communication are of paramount importance.

The playbook for managing these crises is learned through experience. Boeing's last major downturn was nearly 20 years ago, when it reduced rates from 595 jetliners in 1999 to 274 by 2003. "There was a lot of chaos during this crisis," a former Boeing supply chain executive tells me. "We didn't have a full appreciation of the complexity of the situation, we didn't thoroughly vet our assumptions, nor did we fully understand the supplier challenges of ramping up after the crisis."

Most Boeing executives who navigated the early-2000s downturn have retired. What about Airbus?

The stunning fact is that it has never faced a major production reduction. This raises the question: Where will these OEMs find the experience and insight to deal with the unprecedented COVID-19 downturn?

And what about supplier risks? It is no surprise that financial pressure is immense, and it is a result of a four-element sequence of events. First, suppliers endured OEM supply chain initiatives over the last decade that squeezed margins and reduced working capital. Then they were asked to invest significant capital to ramp up production as Boeing and Airbus girded for a future of 60-70 single-aisles per month. This was followed by the 737 MAX production shutdown early this year. Now COVID-19.

Chris Celtruda, a veteran industry executive, recently stated that 20% of jetliner suppliers could fail because of the pandemic. If he is correct, a commercial supply chain crisis could morph into a defense-industrial base crisis in the U.S. and Europe as crucial sub-tier suppliers fail.

For those suppliers that navigate the storm, major questions loom regarding operations. Should they believe OEM production-rate guidance? Should they commit precious capital to long-lead items or conserve cash? What is the appropriate level of production capacity? How deeply should they cut their workforce?

Finally, suppliers face the same experience gap as OEMs. How many leadership teams have managed through a major production downturn? Are owners—particularly private equity firms—patient enough to invest for the future and see this through?

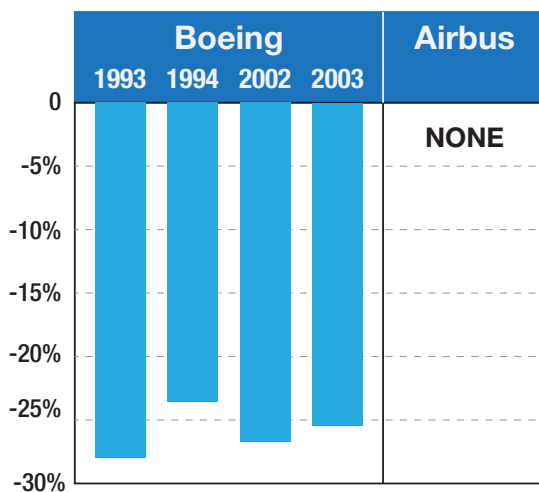
All these risks point to the fact that the underappreciated supply chain function could be the most important within OEMs for the foreseeable future. These organizations must navigate an unprecedented crisis and prepare for and shape a post-COVID supply chain.

"OEMs have the power to pick and choose winners on the other side of the crisis," supply chain guru Cliff Collier says. "And they need suppliers that are financially solvent and able to invest. This means they will no longer be able to select suppliers primarily based on price." 

Contributing columnist Kevin Michaels is managing director of AeroDynamic Advisory in Ann Arbor, Michigan.

Hidden Risks

Unpacking the many
COVID-19 supply chain dangers

Major Jetliner Production Reductions*
Since 1990

*Unit volume reduction of 20% or more

Source: Teal Group



GOING CONCERNS MICHAEL BRUNO

DOES WESTERN AEROSPACE AND defense need to be better protected against Chinese investment? Should Washington directly invest in the U.S.

defense industrial base? Does anyone know how a nationally reliable, albeit not centrally planned A&D marketplace works? So far, on the year-plus journey to a “trusted capital marketplace,” the questions seem to outnumber the answers exponentially.

The U.S. is girding to ward off China’s influence on the Western aerospace ecosystem after COVID-19. But as a recent Aviation Week Network webinar illustrates, there is a long way to go before the right balance is achieved and the risk of messing up the world’s leading aviation, space and defense supply base abates.

“How far are we into the marathon? I think 15-20%,” AirFinance Managing Partner Kirsten Bartok Touw said during the webinar. “We’re still figuring it out.”

Wall of Greenbacks

Is the **U.S. A&D sector at risk** of Chinese investors flooding in?

Tom Mayor, industrial manufacturing strategy practice leader at KPMG, agreed with the analogy. “We have to create a level playing field with a rapidly growing global competitor,” he said during the webinar. “We can’t break the global economy while doing it. So we’re going to have to step our way to leveling that playing field.”

COVID-19 has made the whole Western A&D sector desperate for liquidity. The commercial side of industry is responsible for 70-80% of total business activity, meaning the entire industrial foundation is being rocked by the novel coronavirus, including the defense industrial base.

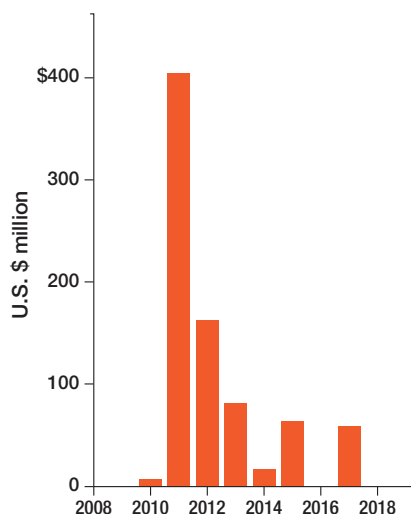
While the Chinese have been investing in the U.S. for years, one fear is they could move in harder now than they have before. “The [2008] financial crisis and subsequent drop in demand for private planes offered opportunities for Chinese investors in the general aviation sector,” notes a May update to bilateral investment trends by the U.S.-supported National Committee on U.S.-China Relations. What is more, the group’s data shows a longstanding, integrated relationship has grown despite wariness on both sides.

What can be done about it? There are no easy answers. The administration of President Donald Trump has had to water down initial chest-thumping proclamations, too, because many questions remain unanswered. For instance, how does the U.S. government exert technological controls without strangling industry? It happened before with satellites in the 1990s, leaving an opportunity for European competitors to emerge and for China to focus on growing its own capabilities.

What about investment? Should the U.S. government have a sovereign wealth fund for A&D companies and startups to fend off Chinese suitors? There is certainly

support within the A&D sector, as evidenced by 76% of participants voting in favor of that premise during the recent Aviation Week webinar. But the new U.S. CARES Act shows it is easier said than done. Corporate America has an allergic reaction to the government getting a direct stake. A&D companies would much rather Uncle Sam pick up the costs of doing business—think tax breaks, export-credit agency guarantees and government-funded research and infrastructure—and let management make decisions while investors reap the profits. Taxpayers and their elected representatives may not agree whether that is enough.

Chinese Investment in the U.S. Aviation Industry 2008-19: \$798 million



Source: National Committee on U.S.-China Relations

Last but not least, saddling up with Uncle Sam could have major ramifications for startups and companies in the aerospace sector. By turning their backs on China, these firms may lose out next decade on what is expected to be the largest aviation system in the world. Additionally, retribution in the form of denying market access could have consequences for overall market health.

KPMG’s Mayor says part of the solution lies in harnessing the West’s unrivaled private equity and venture capital investment arena, along the lines of the “trusted capital” network being talked about in Washington. Touw expects whole new government agencies and institutions to emerge along the way. Both agree more U.S. action is almost certain.

It could be a paradigm shift for a country that, A&D subsidies aside, has little history of industrial policy-making. But as Touw said: “We gradually need to take more thought leadership in this space, more encouragement of the industrial base that we want to develop, and then actually start to make some investments and [be] even more active.”



LEADING EDGE

GRAHAM WARWICK

THE RATIONALE FOR UNMANNING

helicopters is pretty compelling. They are often used for repetitive tasks such as lifting loads, and their operating hours are limited by the pilots and not the machines. But the task of unmanning helicopters is challenging because they tend to operate at low altitude in obstacle-rich environments.

Kaman flew the first pilotless helicopter in 1957, a remotely controlled HTK-1. In 2011, an unmanned version of the company's K-Max external-lift helicopter deployed to Afghanistan with the U.S. Marine Corps. Over 33 months, two helicopters carried more than 4.5 million lb. of supplies to forward bases.

Now, Kaman is developing a heavy-duty commercial unmanned aircraft system (UAS) based on the FAA-certified K-Max. Flight testing is expected to begin in July or August, and the 12,000-lb. optionally piloted aircraft (see diagram) is expected to be on the market in 2021.

Load Lifter

Kaman is developing an optionally piloted K-Max

"We have five systems already spoken for," Romin Dasmalchi, senior director of government business development, told a Helicopter Association International webinar on June 4. Kaman sees roles in firefighting, humanitarian assistance, oil and gas, logistics and medical missions.

Kaman plans to certify the K-Max as an optionally piloted aircraft so it can be flown manned to a work site and be converted there to unmanned operation to continue flying into darkness or deteriorating weather. Dasmalchi cites the example of being able to continue fighting fires into the night.

The unmanned system is being developed by Kaman and an unidentified partner using commercial off-the-shelf technology. "There are components that have already been out there flying for a long time. It saves money, it saves weight, and you get better reliability and redundancy," Dasmalchi said.

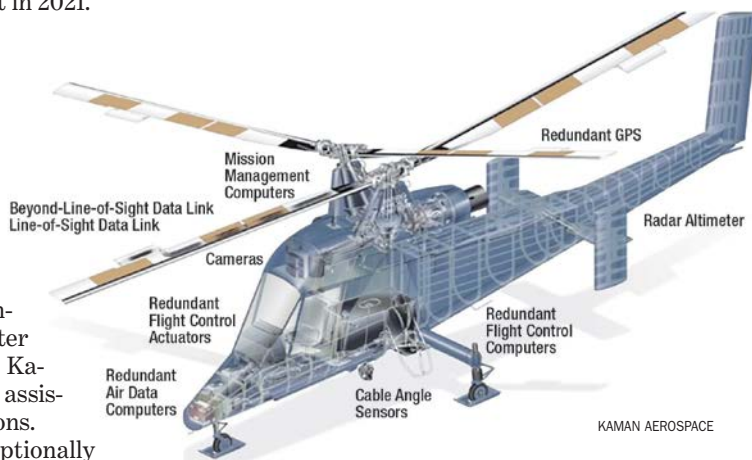
Kaman completed critical design reviews in December for the hardware and February for the software. A ground-test readiness review was conducted in April, and installation of the system in the aircraft is planned to be completed in June. "We've moved along nicely, even with the pandemic," he said.

The K-Max UAS is modified with a mission computer, dual flight-control computers, and line-of-sight and beyond-line-of-sight data link transceivers. Dual air-data computers, GPS/inertial sensors and a radar altimeter are installed. Redundant electric actuators are fitted to the pilot controls.

A camera under the fuselage provides a view of the slung load, which is carried on a cargo hook attached to a trolley that allows the external load to swing laterally. This maximizes the power available to lift loads and helps the pilot maintain control of the slung load, Dasmalchi said.

In the cockpit, a camera provides the ground-station operator with a first-person view through the windscreen. Another camera provides a view of the gauges on the instrument panel. A portable maintenance computer provides a backup cockpit view to the ground control station.

Development of the commercial heavy-duty UAS builds on experimentation underway with the U.S. Marine Corps using two unmanned K-Maxes originally produced for the Office of Naval Research. The two helicopters were deployed to Afghanistan in 2011-14, carrying more than 4.5 million lb. of cargo.



In May 2019, Kaman was awarded a contract to return the two aircraft to service and replace the original Lockheed Martin-developed unmanned system with updated equipment. The helicopters, designated CQ-24As, are being used to develop autonomy technology for unmanned air logistics.

Initially, the optionally piloted K-Max—certified under FAA Part 21.17b—will have GPS-based autonomy, navigating via waypoints that are preprogrammed but which can be changed in flight by the ground operator. Under the Marine Corps program, Kaman is experimenting with sensor-based detect-and-avoid technology, a capability that could in the future be incorporated into the commercial K-Max UAS.

Higher levels of autonomy, such as those being developed and demonstrated by Lockheed Martin company Sikorsky under its Matrix Technology program, are needed to unlock the full potential of unmanned rotorcraft. But once certified, the K-Max heavy-lift UAS will represent a significant step forward for unmanned aviation—64 years after the HTK-1. 🚁



The Next Bomber?

> “ARSENAL PLANE” PROTOTYPING
BUDGET IN DISCUSSION

> AFRL DEMONSTRATED NEW
CLEAVER MUNITION

STAFF SGT. JACOB BAILEY/U.S. AIR FORCE

Steve Trimble Washington

An “Arsenal Plane” has rapidly emerged as a short-term priority for the U.S. Air Force, but an internal debate continues over the type of aircraft to use, potentially affecting the service’s existing command structure and the Northrop Grumman B-21 program.

A proposal to modify Lockheed C-130s and Boeing C-17s to air-drop existing and new long-range munitions is now favored as a short-term solution by the Air Force Warfighting Integration Capability (AFWIC) office, which is charged with developing new operational concepts by the Air Staff.

Air Force Global Strike Command (AFGSC), which has responsibility for the bomber fleet and inventory of intercontinental ballistic missiles, prefers developing a new aircraft optimized for the mission, rather than seeking to borrow strike capacity from an already overburdened air mobility fleet.

Neither proposal is endorsed by the Mitchell Institute, the think tank arm of the Air Force Association (AFA). In a prepublication report obtained by Aviation Week, Col. (ret.) Mark Gunzinger, the institute’s director of Future Aerospace Concepts and Capability Assessments, argues the most cost-effective solution is to buy more B-21 bombers rather than invest

in more long-range munitions to support the Arsenal Plane concept.

All the parties involved agree that the airborne component of the Air Force’s long-range strike capability is inadequate, even after Northrop Grumman delivers at least 100 B-21s, which are expected to replace a fleet of 20 Northrop B-2s and 62 Rockwell B-1Bs and operate alongside about 75 Boeing B-52s.

“What we see is that no matter how big our bomber force is, the capacity that the Joint Force needs is always more and more,” says Maj. Gen. Clinton Hinote, deputy director of the AFWIC, which develops new operational concepts with the Air Staff.

The Air Force’s latest estimate of the requirement calls for a fleet of at least 220 bombers, Gen. Timothy Ray, the head of AFGSC, told reporters in early April.

According to a fleet forecast in the Mitchell Institute report, the Air Force inventory could decline to about

Air-dropping palletized munitions from C-17s and C-130s is one option for solving a strike-power capacity problem.

120 bombers by 2032 as the B-2 and B-1B fleets are retired.

Gunzinger, a former bomber pilot, forecasts the Air Force will order about 120 B-21s by 2040. Combined with 75 B-52s, however, the fleet would still be about 30 aircraft short of the minimum deemed required by the Air Force today. Closing that gap—either by loading long-range munitions on existing airlifters, developing a new aircraft for that purpose or buying more B-21s—is driving the internal debate.

At its core, the debate is over cost-effectiveness and capacity. A stealthy bomber such as the B-21A is more expensive than an Arsenal Plane but needs less expensive, unpowered munitions because they can be released closer to the target. On the other hand, the B-21A is still in the early development phase, so Northrop may need more than a decade to deliver a significant number of aircraft.

In 2006, the Congressional Budget Office considered an Arsenal Aircraft based on a Boeing C-17 loaded with a supersonic cruise missile and concluded that it would be less effective than

A new estimate of the U.S. Air Force's bomber inventory shows a long-term shortfall, which is prompting calls to bolster capacity by adding an Arsenal Plane or buying more B-21s.

a penetrating bomber and require an extra \$3.5 billion to order more C-17s.

As the Pentagon locked in requirements for the B-21A program four years later, an Air Force-funded study by Rand compared the costs of a penetrating bomber versus an Arsenal Plane concept. If the U.S. military engages in at least 20 days of airstrikes over a 30-year period, the 2010 study concluded a penetrating bomber would be more affordable than the required investment in the Arsenal Plane.

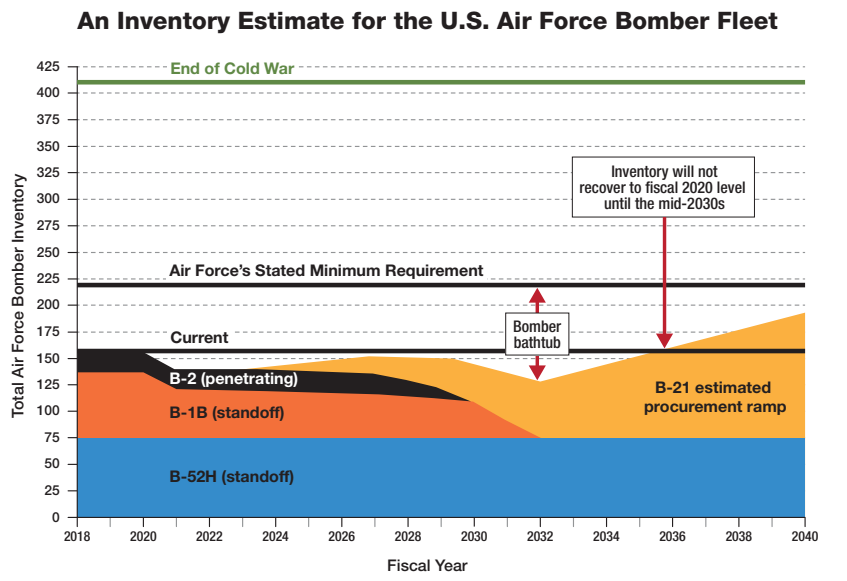
Even though the Air Force awarded Northrop a contract to develop the B-21A in October 2015, however, the debate has continued. Will Roper, then director of the Strategic Capabilities Office within the Office of the Secretary of Defense, unveiled an Arsenal Plane concept in February 2016, showing a Lockheed C-130-like aircraft dispensing palletized munitions.

A year later, Roper became assistant secretary of the Air Force for acquisition, technology and logistics, and the Arsenal Plane moved to the Air Force Research Laboratory (AFRL). In January, the AFRL completed the first test of a new palletized munition dropped by an MC-130J. A picture of the new weapon—the Cargo Launch Expendable Air Vehicles with Extended Range (Cleaver)—showed six munitions on each pallet. A follow-up test involving an airdrop from C-17s was scheduled in April.

The Cleaver testing satisfied AFRL that C-130s and C-17s could adapt one of the core capabilities for both aircraft: airdrop. The C-17 also has demonstrated the capability to release air-launched rockets from the cargo bay. In 2006, a C-17 was used to airdrop a launcher for a hypersonic boost-glide missile. The aircraft also is used by the Missile Defense Agency to test interceptors by dropping surrogates of medium-range ballistic missiles.

The AFRL completed the tests weeks before the Defense Department completed plans for the fiscal 2022 budget proposal. “We are in discussions right now about how we proceed to prototyping and fielding,” Hinote says.

For AFWIC, arming C-130s and C-17s with long-range weapons is attractive



Source: Mitchell Institute

because it can increase munition capacity significantly in the near term.

“It’s all about capacity and that you’ve got to create enough capacity so that long-range punch is really a punch,” Hinote says. “This is why we think that there’s a real possibility here for using cargo platforms to be able to increase the capacity of fires.”

Not everyone agrees with that approach. As the commander of the Air Force’s bomber fleet, Ray told reporters in early April that he does not want a commander to have to choose between using a C-17 for either weapons or airlift capacity.

“When you think about using a cargo plane, you’re in competition for other

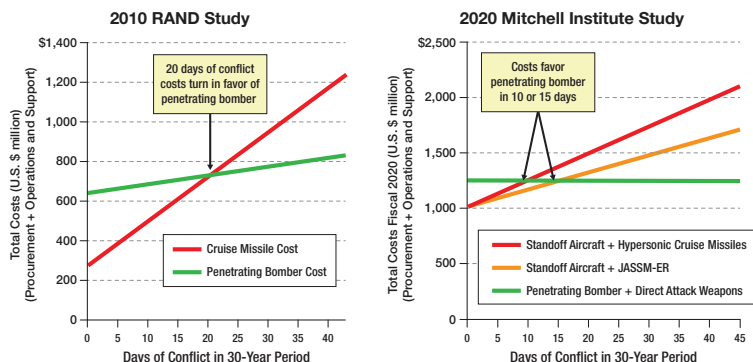
some airpower experts still reject the idea that anything less than a stealthy bomber is adequate.

Instead of lobbing long-range missiles, the B-21 is designed to get close enough to a target to use short-range, direct-attack weapons. Such munitions do not need to carry fuel and propulsion systems and thus can be smaller in proportion to the size of their warhead.

“Size matters, since the number of weapons that can be delivered per aircraft sortie decreases as weapon size increases,” Gunzinger writes in the Mitchell Institute report.

In addition to capacity, Gunzinger also questions the cost of an Arsenal Plane’s required inventory of long-

Cost of Bombers vs. Cruise Missiles



Sources: RAND and Mitchell Institute

airlift requirements,” Ray said. “I think the Arsenal Plane concept is probably better defined as more of a clean-sheet approach to a platform that can affordably and rapidly fill the gap.”

While Hinote and Ray debate whether an existing or clean-sheet design is better for an Arsenal Plane,

range munitions, versus a bomber’s more affordable, precision-guided bombs. A conflict with China or Russia could generate a massive list of targets.

“Using tens of thousands of very long-range standoff weapons that cost a million dollars or more each is simply not affordable,” Gunzinger writes. ☞

FABLES OF THE RECONSTRUCTION

> AIRLINES MAY LOSE \$100 BILLION THROUGH 2021

> ANNUAL PASSENGER TOTAL IS



Rebuilding airline networks will take time and will be affected by new, highly volatile variables.

Jens Flottau Frankfurt, **Adrian Schofield** Auckland, **Ben Goldstein** and **Sean Broderick** Washington

The airline industry remains in the early stages of an unprecedented crisis. Demand, while beginning to recover, remains minimal, and cash is flowing out at stunning speed. A wave of bankruptcies has yet to materialize, but only because governments were quick to bail out airlines identified as being too big, or too economically important, to fail.

Now that there are early signs of recovery, airlines face their next major challenge—quickly rebuilding networks that took decades to construct and optimize. Among the key

questions they are pondering: Which markets should come back online first, and how should they be served? Does local traffic have priority over connecting markets or vice versa?

Which aircraft should be flown? And how much of the rebuilding can be modeled on past flows?

The answers, much like the recovery's expected path, will differ based on specific circumstances.

"Normally, network planning is one-third math, one-third trial and error and one-third gut feeling," says Philipp Goedeking, managing director of consultancy Avinomics. "During the coronavirus pandemic, it's really only 10% math. There will have to be a lot of experimenting."

CONNECTION

REVERTING TO THE 2006 LEVEL



JOERISSA/AVIATION.NET

travel restrictions have begun to come down in many parts of the world, most remain in place for long-haul flying. That shifts the focus to domestic and short-haul operations. Lufthansa, for example, recorded less than 2% of its normal traffic in April but is now expanding to 15% in the second half of June. Published schedules through September have capacity back to 40% of precrisis levels, but the airline will serve 70% of its previous long-haul points and 90% of European destinations. In other words, its network will be broad but not deep. Many markets will be served but at low frequency.

That pattern is popular with other carriers operating different business models. EasyJet is flying 30% of normal July-September levels but will be covering 75% of its network by August.

Given the trend of broad but limited demand, European airlines are restarting their networks with small aircraft. Beginning June 15, Austrian Airlines is operating the first routes, after an almost complete three-month lock-down, using mainly Embraer 190s and de Havilland Dash 8-400s.

Another element of pandemic-induced passenger behavior wreaking havoc on airline planning is last-minute booking. International Air Transport Association (IATA) data show a preference for very late booking—61%

standstill with little data to support forward-booking estimates has airline leaders understandably nervous. Some contend that discounting will not help the recovery, because the demand dip is more linked to health concerns than economic considerations.

Despite this, and perhaps in response to historically low load factors even with major capacity reductions, fares are falling. IATA figures showed domestic ticket prices were down 23% in May compared to a year ago. International fares did not drop as fast, but a near-complete lack of capacity to sell likely helped support pricing.

Many airlines expect international ticket prices to drop, too, as capacity begins to return over the coming weeks. Europe, in particular, bears watching as more governments move to lift travel restrictions.

While each region will face unique sets of restrictions and COVID-19-contamination risks that will influence how airlines proceed, several general global trends are expected to emerge. Domestic routes will generally recover first, followed by short-haul international markets, with most long-haul services lagging. Leisure-traffic demand will lead recovery in many regions, as individuals relieve pent-up urges of wanderlust while companies remain conservative with travel budgets.

Across networks, frequencies will build slowly, and in some cases—the U.S. being a primary example—the larger airlines' desires to rebuild balance sheets will take priority over replicating prepandemic capacity.

The Asia-Pacific region is following the pattern, with many domestic markets bouncing back quickly as internal

travel restrictions ease and airlines reestablish routes, generally with fewer frequencies. Attention is shifting to the more complicated question of how and when international services can be restored.

ASIA-PACIFIC

Several Asia-Pacific airlines have begun to tentatively add more routes to their bare bones international networks, even though travel restrictions have yet to ease significantly.

Restarting with low frequency al-

Projected 2020 Airline Performance By Region

Region	Passenger Demand (revenue passenger kilometers)	Passenger Capacity (available seat kilometers)	Net Profit (U.S. \$ billion)
AFRICA	-58.5%	-50.4%	-\$2.0
ASIA-PACIFIC	-53.8	-39.2	-29.0
EUROPE	-56.4	-42.9	-21.5
LATIN AMERICA	-57.4	-43.3	-4.0
MIDDLE EAST	-56.1	-46.1	-4.8
NORTH AMERICA	-52.6	-35.2	-23.1
GLOBAL	-54.7	-40.4	-\$84.3

Source: IATA

For hub carriers, a top-to-bottom rebuild should, in theory, start with long-haul connections, as they have the most logistical limitations. Asia-Pacific evening departures arrive in Europe in the morning and must be timed to abide by curfews while maximizing passenger connections. Most lucrative are long-haul-to-long-haul connections, in this case Asia via Europe to North America or Africa.

But the pandemic's realities mean this theory must be altered significantly. While domestic and regional

of passengers are buying their tickets within three days of departure, compared to 46% before the crisis. The share of passengers booking 12 days or more prior to their planned flight, is down to 8% from 20%.

The shift means visibility of actual loads is more limited than before, but there is also more significant upward potential right up to departure. Historical volumes for specific city pairs at certain times of the day are also of limited value.

Coming out of an almost complete

lows these airlines to meet the limited demand that exists while positioning themselves to respond when more markets reopen. In some cases, airlines have been initially focusing on routes that have strong cargo and passenger demand.

For most carriers in the region, strategies to rebuild international networks will depend heavily on government decisions to reduce cross-border restrictions. Asia-Pacific countries have widely contrasting rates of progress in containing the pandemic, meaning restrictions will ease at different times

through their airports starting in June. Most foreign travelers will not be allowed to end their journeys in Hong Kong or Singapore, but they will be able to connect there.

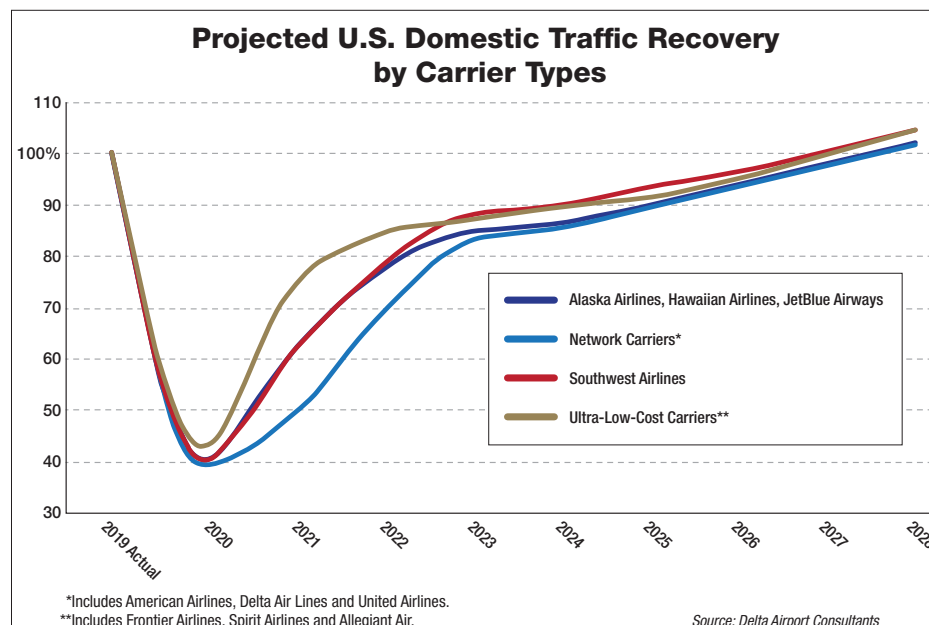
This is an important step for Cathay and SIA. Although many of their key markets for connecting flights remain closed, they can position themselves to capture transit traffic as it begins to return. They can also ensure that other major connecting hubs in Asia and elsewhere do not steal a march on them and gain a competitive advantage.

international service due to COVID-19 concerns. The rules were eased slightly on June 8, but carriers are still limited to a few weekly flights.

Korean Air and Asiana Airlines said in May they intended to add several flights to mainland China to their June schedule, if approvals could be obtained. But because the restrictions were not loosened sufficiently, both airlines were forced to shelve these plans. Their schedules now list one route each through July.

This situation highlights that resuming international services will require flexibility for many Asian airlines. Plans will often have to be changed at short notice if governments do not open borders as expected, or if new spikes in coronavirus cases arise.

Meanwhile, Australia and New Zealand plan to establish a travel bubble that would allow all passengers to fly between the two countries with no quarantine requirements. Qantas CEO Alan Joyce says if it is successful, this could be a template for opening other international markets one by one. A joint industry/government working group with representatives from both countries has presented a report on how the travel bubble could be implemented.



and will often be difficult to predict.

Singapore Airlines (SIA) and Cathay Pacific are particularly focused on international markets reopening, as they have no domestic networks. Cathay Chairman Patrick Healy says that the carrier is “even more vulnerable” to international restrictions than others because it is “wholly reliant on cross-border travel.” In most cases, there is little clarity on when and how restrictions in other markets will be lifted, SIA CEO Goh Choon Phong says. This adds a major challenge to network recovery planning.

SIA and Cathay also have a higher proportion of international transit traffic via their hubs than most other airlines. They rely on connecting traffic flows, such as those between Western Europe and Australasia.

Singapore and Hong Kong both decided to allow transit passengers

Discussions have begun among some Asia-Pacific governments about easing border and quarantine restrictions to allow some essential travel to resume. These will initially be bilateral arrangements between countries so that procedures and safeguards can be rigorously monitored. Such programs may expand to multilateral agreements in the longer term.

China and South Korea were among the first to establish protocols for approved essential business travelers, starting May 1. China and Singapore began a similar program in early June. These three countries are also holding talks with other Asia-Pacific countries with a view to forming essential travel agreements.

For many Asian airlines, access to China is vital to their networks, and they want to begin reopening routes to Chinese cities. However, the Chinese government has heavily restricted in-

NORTH AMERICA

In the U.S., carriers are restoring capacity at an uneven pace, largely depending on their relative exposure to international flying. Canada-U.S. flying remains off limits to all but essential travelers, cutting off a major market for carriers from both countries; Air Canada generates 22% of its annual revenues from U.S. flying.

Among the Big Three U.S. legacy carriers, American Airlines is adding back flights most aggressively in July, with plans to operate 55% of its domestic schedule, boosted by a heavier focus on domestic flying. Delta Air Lines and United Airlines—with greater exposure to long-haul markets across the Atlantic and Pacific—are taking a more conservative stance, adding back 37% and 30% of domestic routes, respectively.

“American Airlines went into the crisis in worse shape than Delta or

United in terms of its balance sheet, but in terms of a domestic rebound, its network exposure is the best of the three,” says Seth Kaplan, an airline analyst with Kaplan Research. “The reality is that Delta and United are structured as more global airlines. That’s a great thing to be when the global economy is going well, but right now, you’d probably rather have American’s network.”

Beyond the Big Three, the country’s domestic carriers are restoring capacity at an accelerated clip in July, bolstering the view that international exposure is a near-term impediment to recovery. Southwest Airlines and JetBlue Airways, for example, will operate 62% and 50% of their respective original schedules, while smaller leisure carriers such as Allegiant Air and Spirit Airlines will operate at 85-90% of last year’s capacity.

More aggressive growth by smaller carriers and conservative advances by the Big Three would be a repeat of the post-Great Recession recovery. Delta Airport Consultants (DAC) sees this as a likely scenario, with one notable exception—Southwest will join its smaller competitors in the more aggressive camp.

The Dallas-based carrier’s current schedule has its late-2020 capacity on par with year-earlier figures. The aggressiveness is a sign that Southwest is prepared to leverage its predominantly domestic network to grab market share from competitors with weaker balance sheets and hubs to rebuild that rely on at least some international feed.

The strategy is reminiscent of the period after 9/11, when Southwest’s labor-cost advantages, combined with financial frailty among its largest U.S. peers, left it in position to strike—and strike it did. While American, Delta and United (and their premerger partners) hobbled along for most of the decade at capacity levels below those of late 2001, Southwest and smaller majors, including Alaska and Hawaiian Airlines, plus the ultra-low-cost segment, grew relative to 2001.

Based on announced aircraft retirements, the fleets of American, Delta and United combined are “likely” to be at least 17% smaller well into 2022, says DAC Chief Industry Strategist William Swelbar. Delta and United have older fleets, while American, with a younger fleet, has nearly

as many leased aircraft as those two plus Southwest combined.

“American’s new fleet, and the expense associated with that fleet, will force it to fly more than the network might support initially,” Swelbar says.

Meanwhile, Southwest has a simpler, domestic-heavy network to stimulate and tremendous fleet flexibility. The carrier has more than 100 older Boeing 737NGs that it could park or keep flying and new 737 MAXs on the way.

“Southwest is the wild card,” Swelbar says. “Will they get smaller, or will they take advantage of the opportunity to increase their share in critical markets?”

Early indications from the airline suggest the latter. “Our progression from April all the way through to the last few weeks of December can basically be thought of as one flat, long, steady ramp-up of capacity,” says Southwest Chief Commercial Officer Andrew Watterson.

DAC’s outlook for the U.S. market projects what it calls a “square-root-shaped” recovery, combining a steep, initial rise followed by years of minimal growth that mimics that math symbol. Strict capacity discipline by the Big Three—Swelbar says annual capacity-increase percentage rates for American, Delta and United may lag behind GDP growth—will keep the U.S. market from becoming a yield-eroding market-share battle.

More headwinds will come from what Swelbar says will be a return of the “hassle factor.” Much as new screening protocols rendered short flights less practical and all flights less convenient after 9/11, new health-screening requirements will add time to travel. The Airports Council International suggests building in 1 hr. or more per departure, at least at the outset.

The bottom-line result from DAC’s model indicates a full recovery to 2019-level traffic figures in 2024 at the earliest, and the networks will not look the same. A conservative approach to growth by the big network carriers, combined with the added burden created by new protocols, could be enough to render some short-haul flying redundant, Swelbar says. The most vulnerable markets are small and nonhub aircraft within 180 mi. of a large or medium hub. There were more than 160

such routes on U.S. schedules before the pandemic.

GLOBAL OUTLOOK

IATA expects the recovery to be slow, with aggregate global airline profitability returning in 2022. Profits then would be “in line with longer-term growth trends for passenger and cargo traffic,” Chief Economist Brian Pearce says.

IATA’s nearer-term outlook sees a relatively steep recovery of global airline traffic, down as much as 95% year-over-year, to a full-year figure of 54% below 2019. Next year, traffic will be 29% below the 2019 baseline, but up 55% from the anomalous 2020 results.

Pearce says the pattern is similar to how the industry emerged from the global financial crisis in 2008 and 2009, albeit with losses at “a much larger scale.”

The IATA guidance is based on several assumptions but contains significant uncertainty. IATA assumes the novel coronavirus can be contained, a second wave of infections can be avoided, and testing will be effective in 2021. The effects of a recession, a slow reopening of markets and a cautious return of business travel are also factored in. Importantly, the forecast is based on a vaccine not yet becoming available through next year. The pace of the recovery could therefore accelerate should a vaccine be found sooner.

Based on the traffic growth, IATA now believes the airline industry will lose \$84 billion in 2020 and \$15.8 billion in 2021, breaking a decade-long streak of full-year profits. The industry made a \$220 billion net profit in 2010-19, and the 2016-19 profit was \$120 billion.

IATA expects 2020 revenues to fall by 50% to \$419 billion in 2020 and climb back to \$598 billion next year.

“Financially, 2020 will go down as the worst year in the history of aviation,” says IATA Director General and CEO Alexandre de Juniac. “On average, every day of this year will add \$230 million to industry losses.”

He estimates that airlines will carry 2.2 billion passengers this year, a full-year mark last seen in 2006, and lose \$37 on every passenger flown. Next year’s passenger count is projected to approach 3.4 billion, or just more than 2014’s annual total. 🗳

Emirates Sees Major Benefits in Tying Up With a Big U.S. Airline

> THE AIRLINE HAS NO PLANS FOR GLOBAL ALLIANCE MEMBERSHIP

> FEEDING U.S. HUBS IS SEEN AS A MAJOR DRIVER OF GROWTH

Sean Broderick Washington and **Jens Flottau** Frankfurt

The relationship between U.S. airlines and Gulf carriers has been hostile for years. Emirates' launch of a fifth-freedom Airbus A380 service from Milan to New York in October 2013 led American Airlines, Delta Air Lines and United Airlines to launch a massive PR campaign about alleged unfair government subsidies for Etihad Airways, Qatar Airways and

huge amounts of business, because we are the single largest producer . . . coming out of the East [beyond Europe] into the United States," Clark says. "There's a huge opportunity there that Emirates could bring to the United States without going into an alliance. It would be a tap that you turned on, sat back and watched us fill large numbers of their airplanes."

domestic feed on one end and Emirates' reach into Asia on the other—could offer similar benefits. But no such deals are in the works.

In 2018, the U.S. signed separate deals with the Qatar and United Arab Emirates governments whereby the Middle Eastern carriers voluntarily share more complete financial information. American and Qatar Airways followed up with the codeshare deal, settling a dispute during which Qatar CEO Akbar Al Baker had threatened to leave Oneworld unless the dispute was resolved to his satisfaction.

With Qatar now tied to American, SkyTeam member Delta and Star Alliance co-founder United remain the most attractive U.S.-based global-carrier partners for Emirates. Clark says Emirates holds no grudges over the subsidy row but suggests the fallout is at least part of the reason Delta and United have not made any commercial overtures. "That's where we are," he says.

But that is probably only part of it. The Star Alliance has relatively strict rules for its members' relationships outside of the alliance. The idea is for them not to enter into agreements that compete too much with members and weaken their market positions. There are exceptions. Singapore Airlines has a codesharing agreement with Air France-KLM, which is part of SkyTeam. Numerous smaller arrangements are focused on feeder services in certain geographies. Emirates, as the largest international airline by available seat kilometers pre-COVID-19, is a wholly different beast. A tie-up with United would be seen as negatively influencing transit flows through European hubs, such as Lufthansa's in Frankfurt and Munich, between North America and Asia.

The same would apply for Delta and its partners Air France-KLM and Virgin Atlantic. Delta owns stakes in the two European groups and has no interest in weakening their business.

The one scenario that seems to elude Emirates—in spite of the complications of trying to convince a member of a global alliance to do business with it—is to join one itself. "People like us have always charted our own destiny and not allowed ourselves to be hamstrung by people who don't think as we do," Clark says. "Our approach has always been, 'If you can't make your own way, then don't bother.'" 🗞

Emirates hopes a tie-up with a big U.S. airline could bolster its Dubai hub.



DUBAI AIRPORTS

Emirates and request the U.S. government to intervene.

The once-massive campaign had become all but unnoticeable before the industry collapsed amid the COVID-19 pandemic. In a highly unusual turn, American and Qatar set aside their publicly traded differences and announced a new codeshare deal at the end of February, an agreement that had been suspended since 2017 in spite of the two carriers' Oneworld alliance membership. Delta and Qatar have been among the largest shareholders of LATAM Airlines, now in bankruptcy. While Etihad is shrinking to boutique-airline status, the big question has been whether Emirates might consider a deal with another U.S. carrier, presumably United or Delta.

Tim Clark, president of Emirates Airline, has a clear answer: Yes. "It makes far more sense to have Emirates deal with one of the Big Three [than join a global alliance] and deliver

Emirates has codeshare agreements and partnerships with several carriers, including Alaska Airlines and JetBlue Airways in the U.S. Clark points to its more extensive link with Oneworld member Qantas as an ideal example of close cooperation that benefits both sides and avoids the constraints of a formal airline alliance.

Emirates and Qantas struck their original deal in 2013 to codeshare and leverage services in Dubai, Perth and Singapore for both carriers' customers. The deal was renewed for another five years in 2018. "The Qantas arrangement is a really good one," Clark says. "It's not an alliance, because it was [developed] bilaterally from a commercial and marketing point of view."

Clark suggests that a similar arrangement with a large U.S. carrier—to leverage major hubs such as Emirates' Dubai base or a U.S. carrier's large European operation, combined with U.S.

Alitalia Has Its Work Cut Out for Post-COVID-19 Relaunch

- > ITALY NATIONALIZED ALITALIA AFTER THE COVID-19 CRISIS HIT
- > THE AIRLINE WILL RELAUNCH WITH €3 BILLION (\$3.4 BILLION) IN INITIAL CAPITAL

Helen Massy-Beresford Paris

When Alitalia filed for bankruptcy in May 2017, unable to stand up to intensifying competition from low-cost carriers in its home market after years of inefficiency, it came as no great surprise to observers of the airline industry.

What nobody would have predicted was that three years later Alitalia would still be clinging to life. Now nationalized, the airline is looking to make a fresh start after a global pandemic that has devastated the commercial air transport industry and led to several airline casualties.

After a fruitless, nearly three-year search for a buyer, Alitalia was hit hard by the COVID-19 crisis as flights ground to a halt. Italy then decided to nationalize the carrier as part of a broader economic support package aimed at helping the country recover from the devastating impact of the coronavirus.

Italy's government has insisted that it does not just want to rescue the airline, which began life in 1947, but to relaunch it as an Italian success story that will also play a key role in boosting the country's tourism sector.

With €3 billion (\$3.3 billion) in funding from the Italian state behind it, the pressure is now on for the "new Alitalia" to prove that is possible. The plan will also come under scrutiny from the European Commission, which could lead to more delays in the relaunch.

For Alitalia to succeed, it will need to follow the lead of its European peers and downsize its operations to fit the new lower-demand environment. The International Air Transport Association (IATA) does not expect air traffic to return to 2019 levels until 2023.

"The government's intention is not yet another rescue of the airline but rather the relaunch of the flag carrier," Economic Development Minister Stefano Patuanelli said last month.

The carrier is planning to approach that relaunch with just over two-thirds of its precrisis fleet of Boeing 777-300ER, 777-200ER, Airbus

A330-200, A319, A320 and A321 and Embraer E175 and E190 aircraft.

"The difficulty is Alitalia isn't starting with a clean sheet of paper," says Patrick Edmond, head of the aviation consultancy Altair Advisory. "It's relaunching as a high-cost carrier."

"It's hard to see how you build any kind of profitable long-haul operation out of Rome when Milan is Italy's economic center. This is something that has hamstrung Alitalia for decades with attempts to operate a two-hub arrangement."

ket," consultant Andrea Giuricin, CEO of TRA Consulting, wrote in a May 27 blog post published on the Istituto Bruno Leoni website.

But with a strong position on only a few transatlantic routes, it is unlikely that getting the Italian carrier back on board will be a priority for the other JV partners, Edmond says. "We've seen, over the last few years, being part of an immunized JV is important for profitability, but Alitalia is not coming to this from a position of strength," Edmond says.

"Long-haul is one of the big assets in which to invest," Patuanelli said in May, also referring to "possible new transatlantic alliances."

Now that the partnership has expired, Alitalia plans to make use of codeshares with Delta to drive traffic.

Alitalia's alliance membership is also more important for the carrier than for SkyTeam itself. "The challenge for Alitalia is that it hasn't been able to

Alitalia is resuming flights after widespread groundings.



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Competition will be fierce as airlines gradually emerge from their widespread groundings, Edmond says.

Long-haul is one of the areas Patuanelli has singled out as a longer-term focus for the new Alitalia. North American destinations are an important area of focus, and the airline will have to look for a way to make up for the loss of a transatlantic joint venture (JV) with Delta Air Lines, Air France and KLM, which ended Dec. 31, 2019. The existing antitrust immunity (ATI) grant between the airlines expired on May 20, 2020.

That exit leaves Alitalia "increasingly isolated in an increasingly tough and competitive air transport mar-

ket," Edmond says. "Once upon a time, decades ago, Alitalia was seen as a stylish and fancy offering. But it will be a challenge to get back to that."

The relaunch of the new Alitalia is just the latest twist in a long-running saga. When the coronavirus crisis hit, Italy's government saw no other option but to nationalize the airline in a bid to save it. The move sent a strong signal: For Italy, allowing Alitalia to go out of business was not an option.

"I think Alitalia may be around for a while, but I don't think that's driven by anything in the air transport space," Edmond says. "I think that's just driven by the political landscape." 🗳

Europe's LCCs Face Obstacles to Summer Recovery

- > AIRLINES START LEGAL ACTION OVER UK QUARANTINE
- > LCCs FACE PRICING PRESSURE AS SUMMER SEASON GETS UNDERWAY

Helen Massy-Beresford Paris

As the summer vacation season begins, Europe's travel landscape is looking very different from previous years: Even if the peak of the COVID-19 pandemic appears to have passed for many countries, Europe's low-cost carriers (LCC) face daunting obstacles to recovery.

According to Eurocontrol statistics, daily flights in Europe are showing the first significant signs of recovery, with four days of more than 6,000 flights at the start of June. That is a drop in the ocean compared with last year's levels. But for airlines, it represents a major improvement on the virtually empty skies of April and May, when most countries were in strict lockdown.

Ryanair plans around 1,000 daily flights from July 1, while EasyJet has said it will resume flights beginning June 15, with about 50% of its 1,022 routes operating in July, although flights will operate at only around 30% of normal July-September capacity.

Some LCCs are even poised to take advantage of the post-COVID-19 environment to further their growth plans: Budapest, Hungary-based LCC Wizz Air, which has been expanding rapidly for some time, is hoping to take advantage of its strength to seize opportunities opened up by the coronavirus crisis, starting with new bases in Larnaca, Cyprus, and at Malpensa Airport in Milan.

"Many carriers don't have any money to invest in anything, but we are benefiting from this situation because we have the financial strength to expand," CEO Jozsef Varadi said in a June 5 interview.

As LCCs take to the skies once again, however, they face significant hurdles.

For example, LCCs that rely heavily on destinations to and from the UK face an immediate obstacle to their recovery from the UK government's decision to impose a 14-day quarantine on most international arrivals.

To no one's surprise, airlines have criticized the measure, and British

Airways, EasyJet and Ryanair have together taken the first step toward legal proceedings, sending a preaction protocol letter to the government June 5 and describing the measures as "disproportionate and unfair on British citizens as well as international visitors arriving in the UK."

The 14-day quarantine came into force June 8, with most residents returning to the UK and visitors required to provide journey and contact

ple, a city break. That risk also applies to visitors to the UK."

The UK government will be reviewing the quarantine measure at the end of June, so it could be removed. But even so, airlines still face barriers to recovery, including the pricing dilemma.

With economic turmoil throughout the region affecting consumer spending power, LCCs will be the obvious choice for cost-conscious consumers who wish to get away this summer.

And after months of lockdown, Europeans do want to get away—recent data released by price comparison site TravelSupermarket.com showed British consumers made 40% more searches for overseas vacation packages for July, August and September in the second part of May, compared with the first two weeks of the month.

LCCs may even benefit from demand from consumers who would

EasyJet is one of three airlines challenging the UK government's quarantine policy.



details and self-isolate their first 14 days in the UK, or face a fine of £1,000 (\$1,300).

Ryanair CEO Michael O'Leary has been vocal in his criticism of the measure, saying on ITV June 3: "What's sad about it is that the British government is introducing this quarantine at the very time when every other European government is removing travel restrictions, is encouraging visitors to visit again and is trying to restart tourism."

Ryanair now expects to carry 75-80 million passengers this year, down from 150 million last year.

"As LCCs gradually reintroduce flights and try to gauge which routes will have the necessary demand to justify those flights, quarantine may act as a demand suppressant," says Nicholas Wyatt, a travel and tourism analyst for GlobalData. "For Ryanair and EasyJet, a lot of bookings are for short trips—a 14-day quarantine does cast doubt on the viability of, for exam-

normally choose to travel long-haul but prefer to stay closer to home amid the ongoing post-pandemic uncertainty. And for newly hesitant travelers, a short point-to-point service is likely to be more appealing than a long-haul flight wearing a mask.

But as LCCs attempt to lure hesitant consumers with low prices—such as EasyJet's one-way flights from London Gatwick Airport to Malaga, Spain, from £22.99—they are increasing their financial pressure at a time when they cannot rely on usual high load factors to make the numbers add up.

"LCCs are very dependent on high load factors, and while I think some level of travel will return, we won't see the load factors we saw before," says Wyatt. Although he thinks LCCs will fare better than legacy counterparts, "I think there will be a big profitability hit," he adds. ☹

—With Kurt Hofmann in Vienna

All SpaceJet Flying Suspended, Production Winding Down to Zero

- SPACEJET MANUFACTURING PLANS WILL FOLLOW CERTIFICATION
- MHI SIGNALS COMMITMENT BY COMPLETING CRJ PROGRAM ACQUISITION



MITSUBISHI AIRCRAFT

Bradley Perrett Beijing

Judging the outlook for the Mitsubishi Aircraft SpaceJet program is not easy, not least because the company itself is unsure of what it will do. Meeting cost-cutting objectives has taken priority even over setting a schedule for achieving airworthiness certification. Yet the commitment to program completion is obvious.

The regional jet program has halted all flight testing worldwide and is winding down production to zero. Staffing at the home of the development effort in Nagoya, Japan, will be reduced, Mitsubishi Aircraft says, briefly outlining its plans to Aviation Week. This follows earlier news that the company would close operations outside Japan, except the main flight-test base, at Moses Lake, Washington, where operations have been reduced to preserving the prototypes there.

On June 1, the industrial group completed its purchase of the Bombardier CRJ program, the likely foundation of future SpaceJet maintenance and marketing. The CRJ business, now called MHI RJ Aviation Group, does not include CRJ manufacturing facilities, which will wind up production of that regional jet this year. Bombardier expected to receive a net profit of C\$550 million (\$410 million) from the sale. MHI would not have chosen to spend that money—as it had on May 7, when it finally agreed to the deal—if it no longer thought the SpaceJet had a future.

The most recent official outlook for first delivery of the SpaceJet has been no earlier than April 2021. With all the prototypes grounded, the question arises of when Mitsubishi Aircraft expects to get a type certificate (TC). The company's answer is that it will

not know until cost targets have been achieved. And it will not know when to resume manufacturing until the regional jet has been declared airworthy.

MHI, which is also the SpaceJet program's airframe-manufacturing contractor, built six prototypes by March, five of which conformed to an original design that program managers had realized in 2016 was not certifiable. Four of those five aircraft are at Moses Lake, where flight testing stopped in April due to the coronavirus pandemic.

Of the two other prototypes, both at Nagoya, one is the crucial sixth unit, which follows the certifiable, updated design and is the main aircraft for the remainder of flight testing. When Mitsubishi Aircraft said on May 25 that it was reducing the Moses Lake operation to preservation of the aircraft there, it said nothing about flight testing at Nagoya.

But Nagoya flight testing had also been halted as a measure to control costs, the company said on June 2 in written answers to Aviation Week questions. The sixth prototype, called FTV10, would stay there, it added.

"There is a possibility that flight testing will begin again in Japan, but [there are] no specific plans yet for resumption of flight-test activities," the company stated. "[The] focus is still on cost control and meeting the budget directives. Once those have been reached, the company will begin rebuilding the plan to reach TC in this new environment."

Announcing its financial results for the year through March 31, MHI said on May 11 it would set an appropriate budget for the program, considering the group's financial headwinds. This "appropriate budget" is what

the commercial-aircraft subsidiary is working toward.

Mitsubishi Aircraft did not directly answer a question as to whether and when flight testing at Moses Lake would resume. Again, the likely answer

The first SpaceJet prototype, pictured here soon after arrival at Moses Lake, is no longer flying.

is that the company does not know. For the moment, it is just keeping the four aircraft there, leaving options open and avoiding the expense of returning them to Japan.

In mid-March, the seventh and eighth SpaceJets—of the same design standard as the sixth—were in the final stages of production. The seventh has now been completed, and work is continuing on the eighth, the company says. Production work on other SpaceJets has been halted—another cost-control measure. No manufacturing activity in the program will take place at all once the eighth aircraft is ready.

"We will revisit the decision on production after we achieve TC and after a thorough evaluation of the new state of the aviation industry," the company says.

Japanese media variously reported last month that SpaceJet production was merely being reduced or that it had stopped only because of delays in receiving parts.

Asked about the size of the development operation at Nagoya, the company says: "There will be impact to our teams in Nagoya, but plans are still in the final stages of evaluation."

On May 11, MHI said it had dropped development of the smaller of the two SpaceJet versions, the M100, which was tailored for the U.S. market. The first version to be certified will be the M90, which is designed to seat 88 passengers in an all-economy arrangement.

The SpaceJet program was launched in 2008, when the type was called the Mitsubishi Regional Jet, or MRJ. SpaceJet losses, which drove MHI into the red in fiscal 2019, are expected to offset profits fully from other activities across the sprawling industrial group in fiscal 2020. ☹️

Check 6 Aviation Week editors discuss whether the regional jet program will survive—and whether its troubles will benefit Embraer. [AviationWeek.com/podcast](https://www.aviationweek.com/podcast)

NASA'S NEW



> SPACEX PREPS FOR OPERATIONAL FLIGHTS

> NASA IS EXTENDING PARTNERSHIPS BEYOND LEO

Irene Klotz Cape Canaveral



LOGO PHOTO: SHUTTERSTOCK

AS THE U.S. DESCENDED INTO ONE OF ITS darkest chapters in recent history, with more than 100,000 Americans dead from the COVID-19 pandemic, unemployment levels not seen since the Great Depression of the 1930s and widespread protests over police brutality and racism, NASA kicked off a space mission that may become as

iconic as the Apollo Moon landing more than 50 years ago.

The success of the new endeavor will be measured not only by its technological achievement—namely restoring U.S. capability to launch astronauts into orbit—but also by its

endurance. By partnering with private companies, NASA seeks to build human exploration and space transportation programs that, unlike Apollo, will never end.

Toward that goal, NASA found kindred spirits in two distinct industries: the fast-paced tech world enshrined by SpaceX and the steadfast aerospace domain of Boeing. Bolstered by about \$8 billion of taxpayer money, the companies took the lead in designing, developing, testing and ultimately flying low-Earth-orbit (LEO) transportation systems for astronauts and other travelers.

The SpaceX solution is attached to the International Space Station (ISS) now, having reached the milestone of a crewed flight test well ahead of Boeing. SpaceX's May 30 launch of NASA astronauts Douglas Hurley and Robert Behnken on a Falcon 9 rocket marked the first orbital launch of humans by a private company and the first launch of astronauts aboard a U.S. spaceship since the space shuttle program ended in 2011.

"It's a little hard to process at this point," SpaceX founder, CEO and

ERA



Former NASA astronaut Karen Nyberg, spouse of Demo-2 Crew Dragon Commander Douglas Hurley, and their son watched the liftoff of Hurley and astronaut Robert Behnken on May 30.

KAREN NYBERG

Chief Engineer Elon Musk said after the launch. "It's difficult to come up with cohesive sentences that make any sense. . . . It's just 'wow'" (*AW&ST* June 1-14, p. 56).

"This is hopefully the first step on a journey toward a civilization on Mars

and life becoming multiplanetary for the first time in the 4.5 billion year history of Earth," Musk adds.

If the ongoing Demonstration Mission-2 (Demo-2) is successful, SpaceX could be ready to fly its first long-duration crew rotation mission on Aug. 30.

"We're at the dawn of a new age, the beginning of a space revolution," says NASA Deputy Administrator Jim Morhard. "This is really something much bigger than all of us. Our hope and prayer is to inspire the next generation, give hope for many people who need it right now."

It is a testament to the preparation of the joint NASA-SpaceX team that in the days leading up to the Falcon 9's 3:22 p.m. EDT liftoff on May 30, the primary concern was the weather. Florida's fickle summertime storm cycle this year started early, dashing plans for an initial launch attempt on May 27. With the potential for rocket-triggered lightning in the skies around Cape Canaveral, the Demo-2 countdown was halted with 16 min. 53 sec. left on the clock.

"It is good for the agency to have a wet dress rehearsal behind us," NASA Administrator Jim Bridenstine said on May 29.

The scrub provided the first demonstration—albeit an unplanned one—of what was once a highly controversial plan to fuel the booster with 1.2 million lb. of superchilled rocket-grade kerosene and liquid oxygen after the astronauts were strapped inside the Crew Dragon capsule perched on the rocket's nose.

The procedure, known as "load and go," was once a showstopper for NASA's Aerospace Safety Advisory Panel (ASAP). The space shuttles'

three liquid-fueled main engines were fueled before astronauts arrived at the launchpad.

"Hearing the venting and the valve sounds and the little vibrations associated with the fueling operation was a new experience for us," Behnken told reporters on June 1.

NASA's safety oversight board also delved into SpaceX's use of an autonomous flight termination system on the Falcon 9, among other issues. Traditionally, the responsibility for triggering destruction of a wayward booster rests in the hands of a range safety officer on the ground.

"SpaceX and Boeing are very different in terms of how they approach systems engineering and integration," ASAP member George Nield tells *Aviation Week*. "The traditional approach is [to] do lots and lots of analysis until you're very confident that everything is going to work as you laid it out."

SpaceX has a more agile process, which is to build something, test it and if it does not work as expected, change it, says Nield. "It can be very frustrating and scary for people used to the other approach because a typical engineer will want to lock down the design right at the beginning and then not change anything going forward."

The traditional approach makes components and systems easier to track since approved designs stay the same. But Nield notes it also "locks you into whatever level of safety—or unsafety—that that system has."

The SpaceX way presented a challenge for NASA as it tried to assess the robustness of the company's systems engineering and integration.

"They came up with something that's really impressive, frankly—a software program they call a 'bill of design' system, which is used for all aspects of the manufacture, the workflow process and the verification review," says Nield, the former head of the FAA's Office of Commercial Space Transportation, which will be licensing the space taxis after they have been certified by NASA.

"Everything is online, so somebody in a certain shift can see what happened in the last shift," says Nield. "It's all tied together through the component drawings, notes and production procedures. And it's all automated so when you get to the end, you can see when this test was done and what the results were, how changing a particular valve has an impact on this other system."

Kathy Lueders, NASA's Commercial Crew Program manager, watched the crewed flight test reach the ISS May 31.



JOEL KOWSKY/NASA



KIM SHIFLET/NASA

Robert Behnken

Age: 49 **Education:** Washington University; California Institute of Technology

Robert Behnken joined the Astronaut Corps in 2000 after serving as a U.S. Air Force test engineer on the Lockheed Martin F-22 and other programs. He flew two space shuttle missions, STS-123 in March 2008 and STS-130 in February 2010, logging more than 708 hr. in orbit and more than 37 hr. spacewalking during six outings.

Behnken, an Air Force colonel with a doctorate in mechanical engineering, served as chief of the Astronaut Office from July 2012 to July 2015 and then became one of four astronauts embedded with both of NASA's Commercial Crew providers, SpaceX and Boeing, working on developing space taxis.

Behnken is now the joint operations commander for the first crewed flight of the SpaceX Crew Dragon, which launched on May 30, 2020. "The thing that's really been the most exciting for me working with the SpaceX team is their ability to react to something that we identify as an area that could be improved, or some area that is a problem—the way that they're able to quickly resolve it," he said during a prelaunch interview.

He is married to NASA astronaut Megan McArthur and father of their six-year-old son, who received a call from his dad shortly after the Dragon reached the ISS. "I just wanted to understand what his experience [of the launch] was and share that a little bit with him while it was still fresh in his mind," Behnken said.

He and Crew Dragon Commander Douglas Hurley could spend up to four months at the ISS, helping out the short-staffed Expedition 63 crew.

In addition, the system automatically catches deviations such as human error in data entry.

"Boy, when some of the longtime NASA managers hear about these things, they're just drooling because they had nothing like that in the era of the shuttle," says Nield. "Everything was manual and on paper. It was very difficult to understand what the impacts of all the various systems were and how to quickly make a change that would roll downhill through all the other systems that were involved.

"It took a while to deploy [the SpaceX system], understand it and implement it completely, but now that it's being used, it is certainly an impressive system," he adds. "They have given NASA almost complete access to that system so they don't even have to be standing here looking over every component being installed or watching every test, because they can go in and check what the status is and understand what the impacts of a particular test are by just questioning that software system."

The harmonic convergence of NASA and SpaceX will be tested throughout the ongoing Demo-2 mission, laying the foundation for cooperation on the Trump administration's signature space initiative, Artemis, and its goal to land two U.S. astronauts—specifically a man and a woman—on the south pole of the Moon in 2024.

About the only surprise from the Demo-2 mission so far was the crew's unexpectedly sporty ride to orbit on the Falcon 9's upper stage, powered by a single Merlin 1D vacuum engine.

"It was a smoother first stage, a little rougher second stage than we saw on the shuttle," says Behnken, the Demo-2 joint operations commander.

"The shuttle had solid rocket boosters to start with, and those burned very rough for the first 2.5 min.," adds Hurley, Crew Dragon commander. "The first stage with Falcon 9, with the nine [liquid-fueled] Merlin engines and roughly the same amount of time, was a much smoother ride.

"Where the differences started . . . was at staging," he continues. "The

ISS Commander Christopher Cassidy, right, and Russian cosmonauts Anatoly Ivanishin, left, and Ivan Vagner, second from left, greeted Demo-2 astronaut Behnken.



With the launch of astronauts Douglas Hurley and Robert Behnken aboard a SpaceX Crew Dragon capsule on May 30, the U.S. nine-year hiatus in human orbital flight came to an end.



BILL INGALLS/NASA



NASA



KIM SHIFFLET/NASA

Douglas Hurley

Age: 53 **Education:** Tulane University

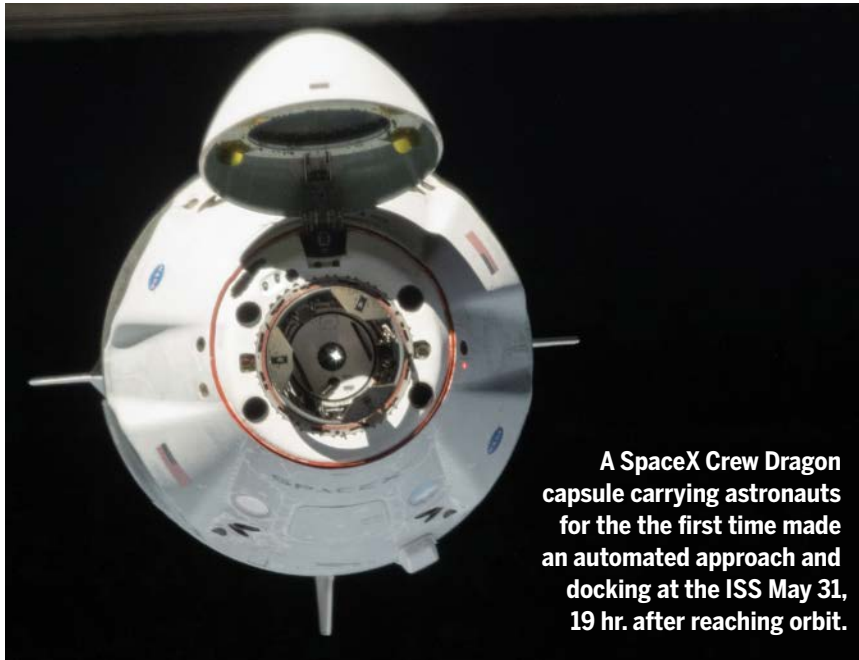
Doug Hurley was selected as an astronaut by NASA in 2000, but it was nine years before he made his way to space as the pilot of STS-127, a July 2009 space shuttle mission to deliver and install the final two components of the Japanese Experiment Module to the International Space Station (ISS).

He returned to space for the shuttle program's STS-135 finale in July 2011, a cumulative time in orbit of more than 648 hr. Nine years later, Hurley found himself in the commander's seat for the first piloted flight test of NASA's Commercial Crew Program.

Hurley, a retired colonel in the Marine Corps, says the time spent as a Boeing F/A-18 E/F Super Hornet test pilot helped him prepare the NASA-SpaceX team, many of whom were conducting their first human spaceflight. "All along in the process that you see in the military, there are delays and technical challenges, and you have to work through them," says Hurley. "There were many reasons why we didn't make the initial [Demo-2] launch date, but that's generally how technological development works."

He launched with fellow astronaut and best friend Robert Behnken onboard a SpaceX Crew Dragon capsule on May 30, 2020, and reached the ISS a day later. "This was an extremely long road for Bob and I," Hurley told reporters during an inflight press conference. "It's taken hard work and dedication over almost nine years to get us where we are now. . . . Take a message from NASA," he added. "Anything is possible."

Hurley is married to retired NASA astronaut Karen Nyberg and is father of their 10-year-old son.



A SpaceX Crew Dragon capsule carrying astronauts for the first time made an automated approach and docking at the ISS May 31, 19 hr. after reaching orbit.

first-stage engine shut off, and then it takes a second between the booster separating and the Merlin vacuum engine starting. At that point, we go from roughly 3g to 0g in half a second, probably. Then when that Merlin vacuum fires, we start accelerating again for the next 5-6 min. until we achieve orbit.

"It'll be interesting to talk to the SpaceX folks to find out why it was a little bit rougher ride on the second stage than it was for the shuttle on those three main engines," Hurley adds.

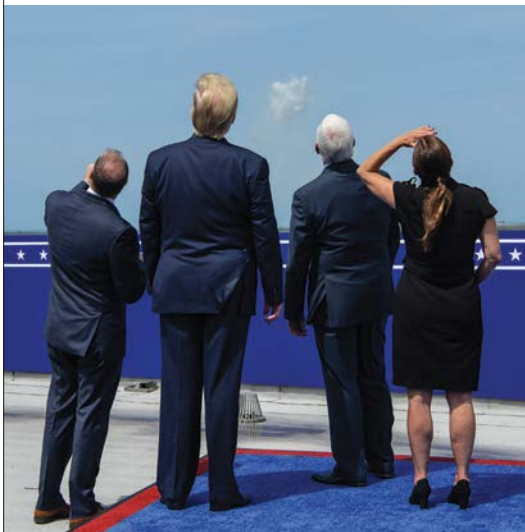
SpaceX's capsule is designed to fly autonomously, but Hurley and Behnken had two opportunities before reaching the ISS to input manual controls, via touch screens, and test the Dragon's handling characteristics. "It flew very well, very crisp . . . just about like the simulators," Hurley radioed to dual Mission Control Centers at SpaceX headquarters in Hawthorne, California, and at the Johnson Space Center in Houston. "It's been a spectacular spaceship so far," he noted on Twitter.

NASA has been preparing for a new chapter in human space exploration since the Columbia Accident Investigation Board in 2003 called for the retirement of the space shuttles as soon as ISS assembly was complete. Initially, the agency planned to have its Orion deep-space capsule, in development since 2006, double as an ISS crew transport.

But facing budgets that would not support both LEO and deep-space transportation initiatives, the agency

began mulling whether the commercial partnering agreements established under the George W. Bush administration to fly cargo to the ISS in the post-shuttle era could be a model for transporting astronauts as well.

In 2010, during the Obama administration, NASA launched the Commercial Crew Development program,



BILL INGALLS/NASA

aiming not only to save money and provide a U.S. alternative to the Russian Soyuz crew transport system but also seed a new industry for commercial space travel.

"The Commercial Crew program has been a great experiment by NASA to see if commercial companies can do this particular job," says former shuttle program manager Wayne

Hale, now a consultant at Special Aerospace Services.

The verdict should be in later this year. Hurley and Behnken transferred to the ongoing Expedition 63 crew, which is short-staffed due to U.S. paid rides on Soyuz coming to an end. The flight readiness of SpaceX's next Crew Dragon will drive how long the Demo-2 mission lasts.

The capsule, which the crew named Endeavour after the retired space shuttle that hosted both astronauts' first flights, is designed to remain in orbit for up to 119 days. Operational vehicles will remain docked to the ISS for six months.

What the U.S. will be like when Hurley and Behnken return is uncertain. Amid ongoing political and economic turmoil, peaceful and not-so-peaceful demonstrations and a deadly virus that has yet to be stemmed, NASA is pressing for a 12% budget hike for the fiscal year beginning Oct. 1 to \$25.2 billion, in an attempt to pull off a crewed lunar landing in 2024.

The parallels between the social unrest and violence of the 1960s and '70s, which became a backdrop for the Apollo Moon landings, and present day are eerily similar. "We have had moments in American history where we have had challenges as a nation," Bridenstine told reporters after the Demo-2 launch. "We think back to

NASA Administrator Jim Bridenstine, left, President Donald Trump, Vice President Mike Pence and Second Lady Karen Pence watched the launch on a balcony at Kennedy Space Center.

the 1960s with the Vietnam War, the civil rights abuses and the civil rights protests. We think about the height of the Cold War. And yet we had this moment in time—July 20, 1969—when all of America stopped, literally just stopped, because we had American astronauts walking on the surface of the Moon. And then we repeated that five more times.

"The Apollo program eventually ended," he adds. "But what is great about NASA is that we bring people together. Everybody loves exploration; it's unifying." 🚀

C-390 MILLENNIUM

READY FOR THE MISSION

It's been a few months since the C-390 MILLENNIUM airlifters started serving the Brazilian Air Force, fulfilling the missions for which they were designed with complete success, and in the coming months more units will join the service. At the same time, the Portuguese Government signed a contract for the acquisition of five units to be operated by the Portuguese Air Force. This is a significant moment in the C-390 MILLENNIUM program, marking its Entry Into Service and the confirmation of the aircraft's operational effectiveness within NATO. The combination of 21st century, state-of-the-art advanced systems and proven engines, in conjunction with a worldwide sustainment alliance of reputable suppliers, makes the C-390 MILLENNIUM the most reliable, easy to operate and efficient aircraft in its class.



WESTERN EDGE

- > TECHNOLOGY BOOSTS AIR-TO-AIR MISSILE SUPREMACY OF THE WEST
- > AESA-BASED ACTIVE SEEKERS ARE LIKELY TO BECOME MORE COMMONPLACE ON MISSILES

Tony Osborne London

PART 2 OF 2

WHEN THEN-SWEDISH

Air Force chief Mats Helgesson declared the MBDA's Meteor beyond-visual-range air-to-air missile in service in 2016, he hailed the weapon as a "game changer" for the country's Saab Gripen fighter fleet.

It meant the Gripen at last had a weapon the Swedish Air Force knew would outrange the air-to-air weapons being fielded by the Russians in the Baltic region.

"It gives us capabilities that we really need to defend our airspace," Helgesson said then. "That means a lot to the air defense of a small country."

The principle of the Meteor's ramjet is relatively simple: At launch, the weapon is boosted to speed by a rocket motor, propelled by fuel that fills the void in the missile case that will ultimately become the ramjet's combustion chamber.

As the weapon builds up to speeds beyond Mach 2 and the rocket propellant is expended, it transitions to ramjet operation, allowing it to be throttled to speeds of Mach 5.

As well as boosting range, this also increases the weapon's lethality, known as its probability of kill (PK), MBDA asserts, because it is able to maintain energy in the final moments of the engagement and react if the target aircraft attempts to maneuver out of the weapon's path.

"The mantra of Meteor was to achieve the range of Phoenix with the agility of Amraam [Advanced Medium-Range Air-to-Air Missile]," says Russ Martin, head of military advisors at MBDA. "If you want to increase range there is compromise; you can add more propellant," he says. "But you cannot keep putting bigger and bigger missiles on fewer and fewer fighters."

Justin Bronk, an airpower and technology research fellow at the London-based Royal United Services Institute says: "What Meteor has done is to

make sure that European air forces at least have a weapon that maintains long-range [beyond-visual-range] superiority over weapons like the [Chinese] PL-15 in a way that the AIM-120 family cannot. I think we will see more ramjet-powered weapons from other manu-



Since its introduction on the Gripen, the MBDA Meteor is now operational on the Eurofighter Typhoon and the Dassault Rafale. Integration for the F-35 is ongoing.

STEFAN KALM/SAAB

facturers in the future as countries look to improve the ability of nonstealthy assets to contribute kinetic fires from outside the highest-threat airspace."

Ramjet technology goes a long way toward resolving the issue of long-range performance with high-end capability without needing an ever-larger aircraft to carry the engines. But it comes with a premium price tag that does not fit every missile need.

Instead, manufacturers are exploring a number of new approaches to extend range.

One of the easiest solutions is to add more fuel to the missile. But this is not easy if the weapon is constrained by the need to maintain form factors, a common issue when a missile is integrated onto advanced combat aircraft with fly-by-wire control systems, for example.

Raytheon's AIM-120 Amraam has kept more or less the same shape throughout its life, but technology has allowed the weapon to expand its range, engagement envelope and PK.

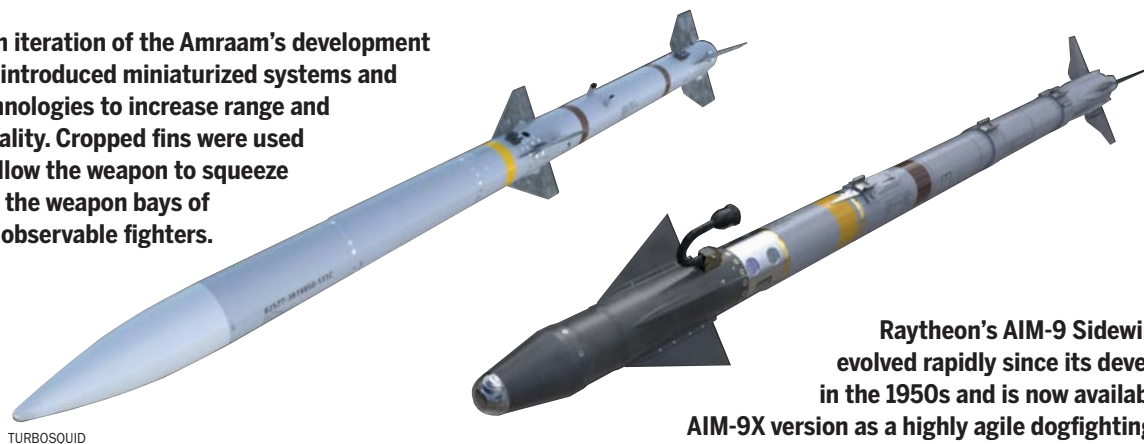
Advancements in modern electronics and miniaturization of components can open additional room in the missile body to squeeze in more propellant. Engineers must strike a balance, however, to maintain the weapon's aerodynamic loading and mass, as well as its center of gravity, as the propellant is used up. Other options to expand range might be to use a different mix of propellants. The Defense Science and Technology Laboratory in the UK has been exploring the use

of a process called Resonant Acoustic Mixing (RAM), which allows propellants and even warhead explosive to be better mixed together.

BAE Systems' experiments with RAM-mixed explosives yielded a 20% increase in explosive power than more traditional forms of mixing. If similar improvements can be made in the mixing of propellant, this could lead to additional space being saved inside a missile body. In the new version of France's Mica NG missile, to debut around 2026, engineers plan to use a dual-pulse motor developed by Roxel that provides the weapon with up to 30% more range. The pulse also can be used to provide more power when dealing with highly maneuverable targets.

Cleaning up weapon aerodynamics is another option. While they look

Each iteration of the Amraam's development has introduced miniaturized systems and technologies to increase range and lethality. Cropped fins were used to allow the weapon to squeeze into the weapon bays of low-observable fighters.



Raytheon's AIM-9 Sidewinder has evolved rapidly since its development in the 1950s and is now available in the AIM-9X version as a highly agile dogfighting missile.

sleek, many air-to-air missiles feature drag-inducing components that allow them to be slid on rails and connect to the aircraft via umbilical cable. That physical connection to the aircraft can potentially be replaced with a wireless one. Such proposals have been suggested for the weapons that might equip Britain's future Tempest combat aircraft.

It remains unclear, however, what technologies have been adopted for the U.S. Air Force's future long-range air-to-air missile—the Lockheed Martin AIM-260. Details of the air intercept missile program, developed as a counter to the Chinese PL-15, were revealed last summer (*AW&ST* July 1-14, 2019, p. 36).

According to the Air Force, the AIM-260 shares similar dimensions with the AIM-120 and provides “significantly greater” range. The service has also said it does not use air-breathing propulsion, leading to speculation about what approach could provide the additional range. Missile experts interviewed by *Aviation Week* suggest several different approaches to the problem, with miniaturization of the weapon's electronics at the top of the list. It is an approach that has already worked well for the weapon that the AIM-260 will go on to replace, the AIM-120.

The Amraam is the West's preeminent long-range air-to-air missile, with 10 kills to its credit. Miniaturization of the Amraam's components has been part of the weapon's development throughout its life. The AIM-120C-7, for example, introduced electronics on round, rather than longitudinal cards, opening additional space. When it came to adding more capability to the Delta model of the weapon, which arrived on the front line in 2015, Raytheon added a bidirectional

data link. That allowed it to communicate back and forth with the launch aircraft, while a conformal antenna on the nose offers a wider field of view to receive targeting updates from more angles in flight.

Other major steps to improve weapon lethality will be the introduction of new technology into radio-frequency (RF) seekers, such as active, electronically scanned array (AESA) technology.

Just as AESAs have revolutionized the fighter's fire-control radar, the technology is able to bring similar benefits to missiles with their lower-energy requirements compared to more conventional active seekers. They are also better able to deal with electronic countermeasures.

“AESA technology has virtually no downsides apart from being a technology that is difficult to master,” says Bronk.

Japan's AAM-4B already has a locally developed AESA seeker. Officials say the weapon can switch to its own guidance at a 40% greater range than the AIM-120, allowing the fighter updating the missile to “snip” the bond between fighter and missile earlier and from a much safer distance—allowing the aircraft to engage another target. The scalability of an AESA means the technology can be used on smaller missiles as well. MBDA is already planning to use an AESA in the RF-guided version of the Mica NG.

In the same way that AESA technology is less prone to jamming, imaging infrared (IIR) technologies can help prevent the missile from being seduced by decoy flares. There is discussion about whether multimode seekers, perhaps combining RF and IIR to work together, could result in weapons less susceptible to countermeasures.

There are costs and technical hurdles to overcome, particularly when it

comes to fitting the technologies into the small nosecone of an air-to-air missile, but Israel's Rafael has taken the first steps. Its Stunner surface-to-air missile, jointly developed with Raytheon, uses both radar and imaging seekers, installed inside an asymmetric nose. It seems likely the technology will make the leap to an air-to-air missile in the coming years, perhaps in the next-generation Python or Derby missiles developed by Rafael.

MBDA is currently advancing the development of the Mica NG, a radically reengineered version of the legacy Mica missile, which was developed in the 1980s and 1990s for the Rafale family (*AW&ST* June 17-30, 2019, p. 102). The Mica was developed through France's experience with the Magic family of IR-guided missiles and the R.530 family of semiactive radar-guided missiles. The Mica, which was developed in two versions—one an IR-guided version, the other an RF-seeker version—makes use of the same airframe but features minor modifications at the nose to package the different seeker heads.

The Mica can be used in both the within-visual-range and beyond-visual-range environment, making it one of only a handful of Western IR-guided missiles designed to operate beyond visual range.

Progressive upgrades have kept the West's shorter-range missiles relevant. Indeed, the alphabet has almost run out of letters to define the number of upgrades for the AIM-9 Sidewinder, now in its 9X derivative. Since the 9X was developed in the early 2000s, Raytheon has adopted a Block upgrade approach to the weapon.

From the AIM-9M to the 9X, Raytheon added thrust-vectoring vanes and flight controls for extreme agility. The company also strength-

ened the airframe to cope with higher G load, with a high-resolution IIR-staring focal plane array seeker in the nose. Raytheon miniaturized several components in the weapon's guidance unit and fuse on the Block 2 upgrade, opening room to add a data link, a technology that is becoming more commonplace even on smaller missiles.

Israel continues to place a premium on highly agile dogfighting missiles, including the Python 5, revealed to the world in 2003, which like the Sidewinder has steadily evolved. The weapon makes use of an IIR seeker that presents a "recognizable" target image, thereby allowing the guidance computer to select the most effective impact point, which is at a point slightly to the rear of the target cockpit canopy, according to Aviation Week reporting.

But it is low-observable aircraft that may drive the next steps in air-to-air missile development. By their very nature, stealthy aircraft can

get closer to their targets than non-stealthy aircraft, but they are compromised by only being able to carry a few weapons in their weapon bays. The Lockheed Martin F-22 Raptor, for example, can carry a maximum of six AIM-120s in its weapon bay and two AIM-9s in the side bays, while the Lockheed Martin F-35 is currently able to carry just four AIM-120s internally, although efforts are underway to enable the carriage of six.

Aircraft such as the Eurofighter Typhoon can carry up to eight air-to-air missiles in different configurations, while Boeing has demonstrated the ability of advanced versions of its F-15 Eagle to carry 16-20 beyond-visual-range missiles in an "arsenal fighter" configuration.

U.S. manufacturers have proposed several smaller weapons that could help aircraft such as the F-22 double their internal missile loads. Raytheon last year proposed the Peregrine, a 6-ft. (1.8-m) missile with a multi-

mode autonomous seeker that could attain the reach of the medium-range AIM-120 and the maneuverability of the short-range AIM-9X. Lockheed Martin has previously unveiled its CUDA concept, a hit-to-kill weapon using technology from the company's PAC-3 missile. It would be equipped with a radar seeker and forward attitude control motors for high agility.

"Smaller missiles could be the next major step," suggests Bronk. "Having spent so much on stealthy aircraft, there is an attractiveness in increasing their cost-effectiveness per kill."

As adversary missiles become smarter, industry is also looking at the need for defensive hard-kill missiles that could be treated like an expendable flare or chaff. MBDA is studying the potential for such systems for Europe's future combat air systems, while the U.S. Air Force issued a call for the development of a Miniature Self-Defense Munition last November (AW&ST Oct. 28-Nov. 10, 2019, p. 57). ☛

Beijing Is Taking Air-to-Air Missile Lead From Russia

- > THE PL-15 IS ONE OF THE PROMPTS FOR AIM-260 DEVELOPMENT
- > CHINESE PROGRESS MAY HAVE SPURRED RENEWED RUSSIAN INVESTMENT

Tony Osborne London

The sight of four long-range air-to-air missiles in the weapons bay of China's Chengdu J-20 low-observable fighter at the Zhuhai Airshow two years ago rang alarm bells among officials throughout the Pentagon.

Their fear was that China's accelerated air-to-air missile work had developed a weapon that could match, or even exceed, the classified range for the most state-of-the-art variant of the U.S. Advanced Medium-Range Air-to-Air Missile (Amraam)—a weapon in service not only with the U.S. but also with several regional allies.

It is not an unreasonable assumption, analysts suggest. In terms of air-to-air missile technologies produced by the U.S.' near-peer adversaries, China is now the one to watch.

"If you look at what the Chinese have invested into air-to-air missile development in terms of intellectual capital and finance, and contrast it with the Russian equivalent, there is no comparison," says Douglas Barrie, an aerospace fellow with the London-based International Institute for Strategic Studies.

Russia's air-to-air missile industry has been steadily getting back on its feet over the past decade. The sector was hobbled by limited investment in the post-Cold War period and largely sustained by exports until the last few years.

Although it has been in development since the end of the Cold War, the Vympel R-77 (AA-12 Adder), also known as Moscow's equivalent to the U.S. Amraam, entered Russian Air

Force service only around 2015. The weapon has since been seen on combat aircraft participating in missions over Syria and on recent Sukhoi Su-35 intercepts in the Baltic Sea. The variant now in service in Russia is the R-77-1 (AA-12B), which is an upgrade of the basic missile. A further development, likely to be designated as the AA-X-12C, Barrie suggests, may also be in testing and destined for use on the Su-57 Felon and the Su-35S Flanker-M.

Russia also needs to address a replacement or modernization plan for the R-73/74 (AA-11A/B Archer) family of short-range missiles, experts say. Although the performance of the Archer surprised the West in the early 1990s because of the way its seeker was combined with a helmet-mounted sight, its lack of imaging infrared (IIR) seeker, which is now a prerequisite for a modern within-visual-range weapon, means it is more vulnerable to countermeasures from those weapons with an IIR seeker. Vympel is said to be working on a new version of the weapon with an IIR seeker.

The Russian Air Force has also taken deliveries of the 200-km-range (120-mi.) Vympel R-37M (AA-13A Axehead). This is an updated version

JUNE 2020

InsideMRO™

SPECIAL MISSION MODS **What's in Demand**

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The March Forward for MRO

My son just graduated from high school during a pandemic, global warming, worldwide recession, and riots in the U.S. following the death of George Floyd. This is far from the environment in which I want to launch him into the world.

His virtual commencement speaker, Chris Cox, former Facebook chief product officer, acknowledged this isn't the ideal time to be graduating but pointed to Isaac Newton, who fled Trinity College in Cambridge to escape the bubonic plague in 1665. While quarantining at home, he created new insights into math—helping to develop what is now calculus. He also stud-

What business improvements will you make during this stressful time?

Aviation Week's Fleet Discovery data shows that the number of parked/reserve aircraft (those flying 1-2 days per week) has increased from 2,670 on May 14 to 3,153 on May 28, meaning that airlines are preparing to resume more flights. Also, in May the 10 largest European airlines showed a fairly steady increase in flight hours but only a very slight increase in cycles, indicating more actual revenue or cargo flights, as opposed to those needed to retain parked/reserve or idle status.

The number of aircraft that have moved into long-term storage has also increased, suggesting that airlines are taking steps to position their assets in accordance with their recovery plans.

Parts sales, especially for those on the lower end of the price spectrum and PMA parts, started to pick up for several companies in May.

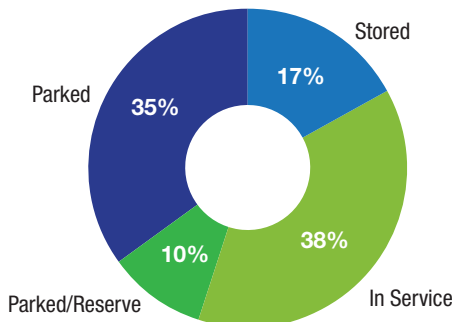
Given that MRO revolves around maintaining the worldwide fleet, gaining an understanding of its composition is a big step forward for the aftermarket. Now we just need people to resume flying.

That process won't happen as regally as the "Pomp and Circumstance" march written by Sir Edward Elgar in 1901, but hopefully the march will be steady. So less pomp, but the circumstances are starting to look positive for our industry's recovery. June should be a good indicator.

Hold your chin up and move forward! 🍀

—Lee Ann Shay

Global Fleet Status



Source: Aviation Week Network Fleet Discovery

ied optics and found that white light is composed of a spectrum of colors. Newton also contemplated how the universe worked and in so doing discovered gravity.

Most people's pandemic productivity is nothing like this, but it is good to focus on what you can do and consider the possibilities. What adjustments and business improvements can you make during this stressful time?

One positive is that airline traffic is starting to rebound. Chinese airlines carried 1.04 million passengers on June 5, the first time this has happened since Jan. 28, according to the Civil Aviation Administration of China.

Highlights

CRJ Aftermarket Support Changes Hands

Bombardier's exit from commercial aerospace was finalized June 1 with the sale of its CRJ aircraft program to Japanese manufacturer Mitsubishi Heavy Industries (MHI) in a deal that includes its maintenance support services.

The sale of the regional jet program became somewhat drawn out, with both parties entering negotiations last year before agreeing on a \$550 million price last October. The deal paves the way for Bombardier to focus solely on business jet production, after offloading all of its commercial aircraft programs—including the Q400 to an affiliate of Longview Aviation Capital in 2019, followed by the sale of its C Series program to Airbus.

Operating as the newly established MHI RJ Aviation Group to be based out of Montreal, MHI will assume control of all maintenance, engineering, airworthiness certification support, refurbishment, asset management, marketing and sales activities for the CRJ. In addition, MHI will take on the regional aircraft's type certificates and related intellectual property rights.

The service centers it picks up as part of this deal will likely further boost MHI's aftermarket network for its own SpaceJet program, which has been hampered by a string of delays owing to technical issues. It is now expected to enter service in either late 2021 or early 2022.

India Tax Changes Seek To Bolster MRO

Indian Finance Minister Nirmala Sitharaman announced, as part of a stimulus plan, a package of initiatives aimed at industrial infrastructure, coal and mineral mining, defense production, civil aviation and aircraft maintenance.

In civil aviation, Sitharaman is aiming to reduce operating costs by \$130 million a year. The minister notes that only 60% of Indian airspace is now available for civil aviation. She wants to ease restrictions so civilian flying becomes more efficient and management of airspace improves to save fuel, time and costs.

The ministry is also seeking to develop world-class airports through public-private partnerships. Six more airports have been identified for a second round of bidding, and Sitharaman expects additional private investment in 12 airports of about \$1.7 billion.

Both airspace and airport improvements would benefit aircraft maintenance indirectly. But the minister also wants India to become a global hub for aircraft MRO. She says the tax regime for the MRO ecosystem has been rationalized, and she expects Indian component repairs and airframe maintenance to increase annual revenue to \$260 million from \$104 million in three years.

Sitharaman's MRO plans also include major engine manufacturers setting up repair facilities in India in the coming year, and a "convergence between defense and the civil MROs" to create economies of scale. Domestic, more efficient MRO should also lower unit maintenance costs for India's airlines.

AAR To Close Duluth Facility

U.S.-based MRO provider AAR plans to close its facility at Duluth, Minnesota, by late July following a decrease in work related to the novel coronavirus pandemic.

AAR says it was informed by a primary customer that due to the global industry downturn, the facility will receive no new maintenance projects at the site "for the foreseeable future."

Once the facility closes, around 275 staff will lose their jobs, AAR says. Staff were informed of the decision to permanently close the shop in mid-May.

The move to shut down the Duluth International Airport site, which AAR opened in 2012 after its previous occupation by Northwest Airlines, represents a step change after the company renewed its lease with the Duluth Economic Development Authority for another 20 years last year.

At the 188,000-ft.² facility, AAR has specialized in Airbus and Boeing narrowbody airframes across six support shops with capacity for up to four narrowbodies at a time. ☒

Briefs

Air Canada completed its final Boeing 767 passenger flight (24307; Montreal-Toronto) on June 2; it operated 767s for 38 years.

Avia Solutions Group, which owns FL Technics and Storm Aviation, has decided to sell **Baltic Ground Services Poland**.

DHL took delivery of an EFW-converted Airbus A330-300F (777; ex-China Eastern), its fourth; it is expected to take two more in 2020 and up to 12 total. It is the first high-gross-weight-converted A330 and has a 62-ton-plus payload. **EFW** received the supplemental type certificate in 2017.

GE Aviation won a \$394 million contract to provide J85 engine supplies for T-38s operated by the **U.S. Air Force** and **Navy**. The T-38 is expected to remain operational until 2040.

GA Telesis created the **Flight Solutions Group (FSG)** by combining its Component Solutions Group (part-outs, parts sales, distribution, flight hour services, inventory leasing, APU management and repair management) with newly formed GAT Logistics Solutions Group (logistics/warehousing) and Tarmac Solutions Group (tooling/GSE). It projects FSG will double its revenue by 2023.

INDIGO is expected to return up to 120 A320ceo-family aircraft to lessors over next two years, to be replaced with A320neos.

ITS plans in late June to tear down an ex-SAS 737-800 (28324) in Wales. It maintains inventories in Chandler, Arizona, and Dublin.

ST Engineering secured S\$838 million (\$603 million) in aerospace contracts in the first quarter of 2020 versus S\$1.3 billion in the same period in 2019. New deals include MRO contracts from Chinese airlines for A320s and CFM56-7Bs and from a Southeast Asian airline for 737 and Q400 component support.

Triumph Systems and Support extended an MRO contract for an international CH-47 Chinook fleet for six more years.

Briefs Source: SpeedNews

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Boeing Exemption Request Eyes 737NG Tailpipe Fire Issue

Boeing has asked the FAA for an exemption that would allow it to modify a 737NG engine exhaust part and permit its installation throughout the CFM56-7 fleet. The upside: The change would cut down on aborted takeoffs (ATO) and other in-service incidents linked to apparent engine fires, and it would save operators money. The downside: The part, and by extension the entire 737NG fleet, would not meet FAA flammability-protection rules.

The complex story dates from 2009, when Boeing learned that its CFM56-7 “long” exhaust did not meet FAA Part 25.863, which calls for minimizing risk of fluid ignition in components where leaks are possible. The issue involved oil

737-700 built in late 2011 and delivered via a lessor to KLM, where it remains in service.

The new exhaust eliminated regulatory-compliance issues, but it introduced other challenges. Among them was that many 737NG operators now had different engine-exhaust configurations, each requiring its own spare parts. It also did nothing to solve the long-exhaust configuration problems.

The CFM56-5-powered Airbus A320ceo-family fleet had a similar issue with its long-exhaust design. Airbus proposed the drain-hole modification, which the European Union Aviation Safety Agency (EASA) accepted. EASA reasoned that the risk

but offered an alternative. “[P]rovided adequate justification is provided, Boeing may wish to consider submitting a request for exemption to 14 CFR 25.863 to allow drain holes to be added to the long-exhaust plug,” Boeing quotes the agency as saying in its reply.

Earlier this year, Boeing submitted its exemption request, including a provision that would allow the new plug to be installed on the entire CFM56-7 fleet.

“The current restrictions on the long-exhaust configuration increase airline operating costs arising from additional inventory cost and configuration management,” Boeing says. “In addition, removing this restriction will allow greater operator flexibility and increased efficiency.”

The new plug would cut down on long-exhaust tailpipe fires and not add risk to the short-exhaust models, Boeing says in its exemption request. Fewer tailpipe fires “would reduce operator unscheduled maintenance, service disruption, and airplane evacuations,” Boeing adds.

In comments on Boeing’s petition, CFM suggests that tailpipe fires are a far greater safety risk than oil dripping on exhaust nozzles.

“In 2019, tailpipe fires were the leading cause of powerplant-caused aborted takeoffs,” the engine-maker says, adding that there have been “at least” 19 such incidents in the last five years. These fires required a full engine overhaul, at a cost of \$4 million, for engines doused in fire-suppression agent.

“The proposed drainage has been demonstrated on a comparative CFM56-powered airplane, and the benign nature of leakage into the exhaust nozzle has been demonstrated on the short-plug version of the 737NG,” CFM adds.

Southwest Airlines, which has more 737NGs in its fleet than any other operator, says the original long-exhaust configuration has caused “several” tailpipe fires.

“These events did not generate a flight deck fire warning indication.

Boeing’s requested exemption would affect the entire 737NG fleet.



buildup in the exhaust plug over time.

In 2011, CFM introduced the CFM56-7BE, which required engine-installation changes to incorporate the new powerplant variant. Among the changes was a shorter exhaust configuration, which includes drain holes and added heat shielding, and meets the regulations. The short-exhaust became standard on 737NG Line No. 3762, which Aviation Week’s Fleet Discovery database shows is a

of fires resulting from oil dripping out of the newly modified plug was less serious than the ATO issues caused by the original, drainless design.

In 2018, Boeing went to the FAA and proposed a similar change for the 737NG engines. Among its arguments was that the long-configuration CFM56-7 fleet was experiencing tailpipe fires eight times more often than the CFM56-5 fleet. The FAA rejected the new plug design as noncompliant

They were typically observed by aircraft located behind the departing aircraft or by passengers, flight attendants and ground personnel,” the airline tells the FAA. “These events could have been easily avoided by placing several simple holes in the exhaust nozzle (to account for engine position and wing dihedral) instead of numerous operational disruptions and unnecessary customer inconvenience.”

Delta Air Lines, which like Southwest operates 737NGs with both exhaust configurations, says the drainage holes “will significantly reduce” tailpipe fires on the older airframes, while a single plug for the entire CFM56-7 fleet “will help to simplify configuration as well as inventory cost.”

Installing the short-exhaust configuration on older 737NGs is pos-

sible, and Boeing has developed a service bulletin detailing the process. But the change is considered a major modification—a costly endeavor with specific record-keeping and other regulatory requirements. Adding a new drain plug to the short-exhaust configuration is as simple as it sounds.

The FAA is reviewing Boeing’s request. ☒

—Sean Broderick

Pandemic Spotlights Cleaning Protocols

A renewed focus on cleaning aircraft interiors has operators paying close attention to what works as a disinfectant and, critically, what is permitted for use on different surfaces. Reports from the front lines suggest significant confusion and, in several cases, airworthiness issues.

A pilot for an unnamed airline filed a NASA Aviation Safety Reporting System report in mid-May detailing an onboard smoke event. “[An] air carrier captain reported smelling a burning smell during cruise,” the report’s summary says. “Post-flight maintenance briefing advised the pilots that alcohol from wipes may be shorting out wires.” The unnamed airline reported that the issue had turned up on “several” aircraft.

Aircraft manufacturers have published procedures on how to clean aircraft and what products to use for years. Events such as SARS and the current COVID-19 pandemic have prompted them to issue reminders and, as lessons are learned, provide updates. For example, Boeing has issued several multi-operator messages since the beginning of the year linked to aircraft cleaning. The OEM’s lists include products that are approved for use and are verified by government health agencies as being effective against the prevailing threat, currently the virus that causes COVID-19.

But some operators are still struggling to follow procedures. An Air Line Pilots Association report issued in mid-

May cited reports of noncompliance at 16 U.S. carriers and one in Canada. Most of the issues concern the frequency and thoroughness of aircraft-interior disinfecting and the materials being used. A common example is pilots being provided with hand wipes that are not on the Environmental Protection Agency’s E-list, which tracks products known to work against the novel coronavirus.

International Civil Aviation Organization guidance on protecting cargo pilots issued May 11, refer to manufacturers’ recommendations.

While the guidance is not new, OEMs say they will work to make it more readily available. An early item on a new Boeing initiative’s to-do list is reaffirming which cleaners and materials are approved for different aircraft surfaces, says Mike Delaney, who is heading up the just-launched Confident Travel Initiative. Boeing says it will push to harmonize recommended product lists as much as possible among manufacturers. The



JAMIE PENNY/ARND BRONKHORST IMAGES

OEMs are issuing guidance on flight deck cleaning best practices.

The FAA and other regulators are hesitant to mandate aircraft-cleaning protocols, referring instead to health agency guidance, which focuses largely on aircraft cabins. Instructions on cleaning flight decks, such as in the

goal, says Delaney, is to give operators choice while ensuring they do not have to stock multiple brands of the same general products to do the same job on different manufacturers’ aircraft. ☒

—Sean Broderick

ARSA UPDATE

Virtual Must Still Relate to Reality

A MODERN WORKDAY INCLUDES COUNTLESS virtual communications—emails, video conferences and meetings, text messaging, social media exchanges, you name it.

In today's environment, the usually busy schedule of industry events has also become an adventure in remote connectivity. Online streaming services are recovering sponsorship and registration revenue lost by the inability to hold in-person gatherings. Trade associations are becoming adept at holding crisis-focused webinars and live-streaming sessions to enable and even stimulate member connection. The Aviation Week Network—no slacker when it comes to reinvention—is producing a slate of webinars that offers a regular venue for the industry to share and revisit predictions, advice, viewpoints and best practices.

The underlying goal of any communication—in-person, audio and visual recordings, streaming or otherwise delivered—is to provide value to a target audience. Adhering to this focus will ensure that the end-user, be it colleagues in the same company or an industry-wide audience, is properly served now and in the future.

An example of the need for improvement was on display May 14. After a week-long delay caused by technical difficulties, the FAA hosted a virtual "Aviation Safety Town Hall." Originally, ARSA's notice about the event included the promise of an exchange with invited panelists. For reasons unknown, when the association's executive director was informed (48 hr. in advance) that the event would be live-streamed on the agency's YouTube channel, there were no engagement instructions of any kind.

The session included two panels moderated by Administrator Steve Dickson and Flight Standards Executive Director Rick Domingo. At its most condensed, the video screen packed in 14 faces: Dickson and Domingo, supported by FAA Assistant Administrator for Communications Brianna Manzelli, were joined by senior executives from air carriers and trade unions including Delta Air Lines, United Airlines and American Airlines as well as the National Air Traffic Controllers Association and the Air Line Pilots Association.

The exchanges were pleasant and generally positive, packed with praise for collaboration and responsiveness from both industry and the government, affirmations (and reaffirmations) of the value of safety management systems and promises to "stick with what we know" in both crisis management and the eventual return to "normal operation." It was a demonstration of intra-industry back-patting about quick action and coordination and the work being done to protect crewmember health and passenger safety.

But who was this supposed to help, advise or encourage? In other words, who or what was the target audience?

There were no media advisories or broad public announcements drawing attention to the session. Only those who already carefully watch FAA communications—or ARSA.org—were even aware of the event. There was no clear agenda or information on content or context. The approach and discussion were too technical and obscure to hearten a nervous flyer. Nor were there any specifics regarding compliance obligations or operational issues that could help a curious certificate holder.

None of the information provided generated broader coverage or discussion. An internet search for "FAA Aviation Safety Town Hall" finds nothing from the usually attentive aviation industry trade press. During the event, Manzelli befuddlingly reminded "media viewers" that all discussions were "on background," a standard phrase meant to prevent reporters from ascribing statements to particular speakers. We appreciate the agency's use of remote technology, but its effort was all virtual and not much reality. Remote connectivity must ultimately ensure that user involvement at least approximates an in-person, on-premises experience. This standard—replicating direct personal experience—will sound familiar to anyone who has followed the industry's broader effort to institute reasonable remote connectivity policy. With care and attention, it can be achieved in a maintenance facility or on a flight line.

On the same day as the FAA event, ARSA Executive Director Sarah MacLeod and I participated in a webinar hosted by our colleagues at Helicopter Association International. Similar to Aviation Week's and other industry offerings, these sessions are readily available to the public, their purpose and participants are known and registration is straightforward. In preparation, the production team provided regular updates to help us keep our presentations relevant. We delivered our session materials early, ran through the technology and prepared to take questions and interact with participants.

The "new" normal demands that the aviation industry and the FAA become capable of using virtual reality, particularly since it is neither new nor virtual. It is a method of communicating that can be the same and in some cases even better (one cannot attend an industry meeting in flip-flops) than an in-person, on-premises experience. ☛

Brett Levanto is vice president of operations with Obadal, Filler, MacLeod & Klein.

Ryanair

In an interview conducted in two parts, one shortly before the novel coronavirus pandemic and one in the middle of it, Ryanair Director of Maintenance and Engineering Karsten Muhlenfeld talks to Inside MRO's James Pozzi about the low-cost carrier's capacity plans and how it has adjusted maintenance operations given the COVID-19 crisis.

In late 2019, Ryanair sent some lines of maintenance outside Europe to Joramco in the Middle East. Was the decision to look beyond Europe for some maintenance requirements a capacity-driven one?

It wasn't solely a capacity issue. We want to operate our capacity in our existing hangars, but if that is fully utilized, then we will naturally have to outsource work. In order to do that, we work with several companies in Europe or close to the continent. Joramco had shown itself to be very efficient and to deliver a very good MRO service; so we decided to try it as a provider. It's the first year we have worked with Joramco. We sent two full scheduled lines of heavy maintenance, and we are happy with what it has delivered.

Joramco isn't the only external supplier we are using, however—we have five other MRO providers undertaking checks for us. We are in a season with significant scheduled maintenance [March 2020], which is fixed, and because of the growth of the fleet at certain times, we have very specific requirements. That means working with external companies.

Ryanair has built up some impressive in-house capabilities on airframes, but is it looking to add more in areas such as parts repairs?

We do the major overhaul of the aircraft and for some parts—for example, an aircraft water boiler—we will repair them in-house at one of our workshops. But for complicated parts related to an aircraft's electronics, we outsource to the OEM, and that won't change. We feel that going to the OEM for these more specialized repairs is a

good solution, as it guarantees we will receive an in-depth level of expertise and product knowledge.

What is the ratio of insourced to outsourced maintenance?

Currently it stands at around 80% of maintenance being done in-house, with the remainder of work outsourced to third parties.

November 2019 saw some issues related to pickle fork cracks on Boeing 737-800 aircraft, which led to three Ryanair-operated aircraft being grounded. Did this issue have a significant effect on your fleet operation?

Our mechanics identified a small number of findings on some aircraft that needed to be repaired and that was for Boeing to repair. From that point of view, it had no impact on us because it was only a small number of aircraft, and occurring during the winter season meant we had some spare aircraft available. Nearly all of our heavy fleet maintenance is done in the winter, so we could afford to send these aircraft to Boeing to be repaired and see no impact.

Given growing internal base maintenance requirements, how is Ryanair looking to address concerns about MRO capacity in its network?

Upon reviewing our heavy maintenance capacity across sites in Prestwick (UK) with five maintenance bays, Kaunas (Lithuania), Wroclaw (Poland) and Seville (each with two bays), we analyzed where it made sense to grow further and decided that we will expand the hangar in Seville by an additional two bays in 2021. We're



RYANAIR

Ryanair Fact File

HISTORY: Ryanair was founded in 1984 and commenced operations the following year. Under the leadership of Michael O'Leary, who joined Ryanair in 1987 before later becoming CEO, the airline has grown to be one of Europe's largest and operates a route network across 40 countries in Europe, North Africa and the Middle East.

FLEET: Before the grounding of its fleet, Ryanair operated 273 Boeing 737-800 aircraft. The wider group has nearly 200 more aircraft, with 120 737-800s operated by Malta Air and 26 Airbus A320-200s operated by Austrian low-cost carrier Lauda. Ryanair is also among the most high-profile customers for Boeing's troubled 737 MAX program, with firm orders for 135 of the next-generation narrowbody in place and options on a further 75. The airline said earlier this year that the service entry of the MAX could be delayed by up to two years, but it remains committed to the program.

MAINTENANCE CAPABILITIES/LOCATIONS:

The airline has more than 70 line maintenance sites, with its four largest locations at London Stansted in the UK, Dublin, Milan Bergamo in Italy and Madrid. Its heavy maintenance operation includes four sites across Europe: Prestwick in Scotland, where it has six lines; Kaunas in Lithuania with two lines; Wroclaw in Poland with two lines; and Seville, Spain, which will expand from its current two lines to four lines by 2021.

MAINTENANCE STAFF: Pre-COVID-19, Ryanair had more than 2,000 engineers in total, comprising 1,100 in heavy maintenance, 800 in line maintenance and 200 staff in logistics, materials and continued airworthiness.

RYANAIR



Ryanair's maintenance plans have been adjusted due to the novel coronavirus pandemic.

also growing capacity in Prestwick from five bays to six bays this year. We've already grown there significantly on the base maintenance side. We've also ramped up our line maintenance network and in the past year or so have added new lines at Milan Bergamo Airport.

Inside MRO spoke again to Karsten Muhlenfeld in May 2020 for an update on how the airline has adapted its main-

tenance operations in the wake of the COVID-19 outbreak.

Ryanair grounded its entire aircraft fleet after the novel coronavirus pandemic led to global travel restrictions. How has this affected your maintenance operations?

We have chosen to put aircraft in short-term storage or in active parking. The procedures are provided by Boeing and

Airbus, and we have followed their instructions. The aircraft are flown regularly, which will allow us to resume operations quite fast once we are able to.

Where is Ryanair parking its aircraft?

We have parked the aircraft at our main bases (located throughout Europe) to ensure that we can perform maintenance efficiently.

What reductions or changes has Ryanair had to make to its maintenance teams due to COVID-19?

The COVID-19 pandemic has created an unprecedented crisis for the aviation industry. We are now facing a new environment of lower fares and distorted competition due to below-cost selling by inefficient airlines propped up by unlawful state aid. Unfortunately, all areas of the business have seen staff reductions in order to adjust to this new environment. ☹️

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DATA FOR LESSORS

How lessors keep track of the data generated by their equipment and improvements they would like to see

Alex Derber London

As airlines prepare to weather a period of lower demand in the aftermath of the COVID-19 pandemic, analysis of aircraft-generated data and other technologies that promote maintenance efficiencies—and lower costs—will become increasingly important. At the same time, the debate about who has access to operating and maintenance data is likely to intensify, with OEMs, MRO providers and airlines all pressing their respective claims.

The value of such data and its analytics for each of the above parties has been well-documented, but less discussed is how aircraft and engine

lessors fit into the picture—something of an anomaly, given that they own a large chunk of the global aircraft and spare engine fleet.

MAINTENANCE DATA

As the owners of their equipment, aircraft and engine lessors are clearly entitled to all of the operating and maintenance data that it generates. Indeed, accurate maintenance and life-cycle records are a crucial part of asset management both in the highly technical sphere of spare engine leasing and for aircraft lessors since the value of aircraft as they age is increasingly tied to that of their engines. And within the engines, much of the value is in their life-limited parts (LLP)



Keeping an eye on utilization data can tell a lessor when an engine comes off wing.

ROLLS-ROYCE

and, crucially, in the proof of those parts' histories.

Accordingly, aircraft and engine lessors usually will conduct periodic on-site checks to ensure customers are keeping up to date with their maintenance records, to inspect maintenance planning documents and to coach them about return conditions. In addition to the physical status of the aircraft, these will also cover and require well-organized and complete maintenance and modification histories as well as back-to-birth traceability for valuable LLPs.

"During a lease, it's our policy to visit our operators once every two years," says Justin Phelan, vice president of marketing for Engine Lease Finance (ELF), one of the largest independent engine lessors. "We look at the LLP sheet, SBs [service bulletins], ADs [airworthiness directives], state of the engine trends and the last borescope [inspection]; and if there was any intervening maintenance work done, we would seek that data to review it."

In most cases, engine lessors have little trouble seeing maintenance records since their leases expressly allow for it. However, Phelan notes that problems sometimes arise when the lessor wants to verify, for example, that no parts manufacturer approval (PMA) parts or designated engineering representative (DER) repairs were used during the overhaul—as this can affect asset value and transferability—and asks to see the "dirty fingerprint" records for parts taken off and installed on the engine.

"At the time of the shop visit, the operator may not have requested a copy of all the dirty-fingerprint records they are entitled to, and at a later date some MROs will charge to take that information out of deep storage," he says.

Phelan adds that one "large" engine MRO provider tried to refuse access to such records citing inspector confidentiality, "even though for the vast majority you can't recognize the person because it is a coded number."

OPERATING DATA

Unlike maintenance records, operating data is generated on a daily basis (at least in normal times) and as a result presents different access challenges. For while most lessors are able to see basic utilization data that shows when their equipment is burning cycles, more detailed information from engine and aircraft sensors is often not so readily available.

"Our leases provide that we get a copy of all data generated by our engines, so strictly speaking we are entitled to see the engine trend monitoring . . . And in theory we would be able to get in on a near real-time basis. But in most cases it doesn't happen like that . . . and that's a function of the operator not giving the OEM the green light to provide that information to us," says Phelan.

Such information might include reports on exhaust gas temperature (EGT) margins, fan speeds and fuel flow, inputs that form a crucial part of engine trend and health monitoring. It also feeds into predictive maintenance models and would allow lessors to conduct more in-depth asset management with better projections, says Phelan.

"You may be approaching a shop visit where you would like to swap out an engine; you may like to avoid a shop visit but take back the engine early," he adds.

And while the lessor can receive all the trend-monitoring data at lease-end, during the lease—when it would be most useful—airlines can be averse to providing it, citing their right to data exclusivity.

"We've been working with airlines on a case-by-case basis to get better access to that data, but some are not forthcoming and say, 'We have the right to quiet enjoyment of the engine, and we can't always push the button that easily and give you the data,'" says Phelan.

Nonetheless, lessors can still glean key insights from the utilization data that is readily available. For example, an engine that suddenly came off wing would suggest a maintenance event that the asset owner would want to follow up on.

"You can do quite a lot that with utilization data—you can make general assumptions—but you can get very bespoke and very granular when you get the precise details," says Phelan.

SHARING AND COLLABORATION

Many aftermarket companies now try to digitize maintenance histories and parts records, either through entering the data into a bespoke platform or simply by scanning paper documents into a PDF format.

ELF uses the latter method, having gone largely paperless about five years ago in favor of a searchable internal database of PDF records than can be accessed via a web portal. Phelan describes the system as "effective and very user-friendly," adding that "nothing we have seen on the market has made our system obsolete yet."

Similar sentiments are expressed often by other players in the aftermarket, but while internal systems can work smoothly for their users, the huge variety of formats and software used by



LUFTHANSA TECHNIK

different companies creates headaches when it comes to sharing data.

Gil Krazier, director for engine lease and trade at Israel Aerospace Industries (IAI), told *Inside MRO* last year that “there is still no clear way to share documents in this industry; each lessor, airline and MRO holds its own solution for documentation, and it can be difficult to access these.”

Reconciling data in the format of one platform with that of another can prove to be a considerable administrative burden, even though the data itself is identical. The burden may sometimes be enough to push airlines to stick with a particular maintenance provider or OEM service because of the weight of accumulated data residing with it and the desire to preserve the integrity of that information. However, if that data is accurate and readily available to all parties, it might reduce barriers to entry for other MRO providers—and thereby increase competition.

The solution to this problem may involve blockchain technology and the provision of a single, immutable source of equipment and parts histories via a distributed ledger that is accessible

to anyone with the appropriate permission. In fact, lessors comprise a particularly appropriate use case for blockchain, given their need for trusted data, their need to audit that data and the existence of multiple actors across their networks.

“I do think blockchain has a lot of merit in it,” says Phelan. “If there is one universally accepted system for the whole industry, that makes things very simple.”

Phelan suggests that a big organization such as a Tier 1 OEM should take the lead in developing such a system, adding that it would probably need the support of the International Air Transport Association, the International Civil Aviation Organization, all the OEMs and many of the larger airlines. In fact, the benefits of blockchain are most evident at scale, although adding more participants may create other difficulties. One is gaining the approvals and agreement on how to structure and launch the system; another is the technology challenge of dynamic security access, since certain parties to a distributed ledger may not always be entitled to view some or all of the information in it.

Engine lessors often struggle to access trend-monitoring data before their leases end.

One way to speed up development of blockchain solutions for life-cycle tracking is to start on a smaller scale than the one envisaged by Phelan. For example, GE and a small number of industry partners are developing a distributed ledger to track the parts in its engines. Given the OEM’s market share, this is a significant development, and some industry observers believe there is still value in setting up initially limited ledgers, as they have the potential to grow organically.

Phelan also notes that broad acceptance has proved to be enough for industry collaborations in the past, such as the incident/accident clearance statement that affirms that a part has not been involved in an accident or subject to certain harmful conditions.

“That’s an example from the past where experts have got together—it isn’t accepted by everybody but it’s by a large swathe; so nothing is perfect, but that’s an example of how you might do it in the future,” he says. ☺

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Pandemic Complications

Lessors and lessees adjust to a new normal for the lease-return process

James Pozzi **London**

Lease returns for aircraft and engines have long been considered complicated and often costly processes. This is due to various factors such as the logistics of redelivering the asset to the right location and then having it inspected by the multiple parties involved in the handover to ensure lease terms are met. Since the outbreak of COVID-19 has restricted the movement of many aerospace assets across borders due to global travel shutdowns, these processes have become more complicated for lessors and lessees alike.



SMBC AERO ENGINE LEASE

“The biggest problem that people are experiencing today is the inability to travel and the inability for people who are traveling to stop off. Moving aircraft and engines around is difficult, as there are a number of countries that are closed,” said Allan Rennie, technical director at asset management specialist KV Aviation, during Aviation Week’s “Assessing the Challenges of Lease Returns” webinar in late April.

Aside from redeploying the asset, getting access to the necessary manpower for the lease-return process is proving to be challenging. “Trying to get technical consultants into a position to actually do a lease return is also very difficult,” Rennie says. “The number of agencies we use are all employing local nationals to do their returns in their hometowns and countries, so as a result the skillset isn’t readily available, depending on where the return is actually taking place.”

Graeme Crickett, chief technology officer of SMBC Aero Engine Lease, also cites manpower issues emerging during the downturn. “Our greatest issue isn’t just trying to find

somebody on-site to do our technical redeliveries for us, but also talking to the airlines,” he says. He attributes this to revenue-starved carriers laying off or furloughing employees in the wake of the novel coronavirus.

Crickett shares pessimism across the industry as a whole about the future for some carriers, with airline insolvencies and financial distress on the horizon, and he foresees the crisis lasting another 3-4 months at least. “Some airlines are not going to recover,” he says, citing a lack of cash, resources or government backing while also believing that some widebody operators could find conditions tough. The knock-on effects of aircraft order cancellations and the lack of new commitments are expected to affect not only OEMs but to a lesser extent some MRO shops, Crickett believes. “They’ve spent years scaling up and now suddenly have to turn back—that’s a huge knock-on effect,” he says. However, Crickett is hopeful that the industry will grasp the opportunity for a greater push toward e-signatures post-COVID-19, which would be a positive change.

Bill Gibson, a partner at law firm Vedder Price, says that before the novel coronavirus, both the redelivery of the asset along with the transition of an aircraft or engine to a follow-on operator were complicated procedures. He cites several reasons why this has been the case, ranging from reaching agreement between the lessor and follow-on lessee about the condition of the asset to “more

The novel coronavirus has created more challenges for lessors such as SMBC.

prosaic” complications such as getting the necessary parties to sign documents and having them notarized or legalized as part of e-registration requirements.

In this still-evolving environment, Gibson says new approaches will be necessary. “If before all of these complications we were having to plan ahead, now we are really having to plan a longer timeline,” he says. However, even now

he is already seeing the impact of COVID-19. “In terms of timing, we are seeing an awful lot of scheduled redeliveries move sideways just because of all these difficulties and at a fluctuant time, and that can create a problem,” he says.

Rennie of KV Aviation believes there likely will not be relief in the short term for these complications and sees them remaining for some time to come. “The difficulties we are seeing now will probably continue for the next 12-18 months until every country relaxes some of their travel and immigration policies,” he says. With the added possibility of further measures being imposed—such as screening passengers pre-flight—there are concerns that this may further deter travelers and lead to a further knock-on effect on the leasing of assets. “There’s going to be another level of complication getting people from A to B and, equally, getting the right people in the right place to do MRO returns, engine returns and aircraft returns—it’s another level of complication that we’ll have to work around.” ☛

Medical Mods

What goes into converting passenger and cargo aircraft for medical missions?

Lindsay Bjerregaard **Chicago**

The novel coronavirus pandemic has seen passenger air traffic fall dramatically, but many operators and MROs are adapting to new demand during the unprecedented situation by pursuing temporary

tensive care, ventilation and disinfection. LHT removed passenger seats, galleys and luggage bins to provide room for a patient transport isolation unit, which was surrounded by an airtight tent with negative pressure as

light enough to be easily handled by two people. The MRO is now in the concept phase to adapt the PTU with EpiShuttle, a single-patient isolation and transport system for providing intensive care monitoring and treatment. The company also says it has been in close contact with several air forces in Europe that are looking for medevac mission solutions for crisis situations such as COVID-19.

Canadian MRO Flying Colours Corp., which has experience converting aircraft ranging in size from the

LUFTHANSA TECHNIK



modifications for cargo conversions and medical transport.

For Lufthansa Technik (LHT), which employs approximately 1,000 people in its VIP and special mission aircraft department, COVID-19 is not the first pandemic to create demand for special aircraft used to transport and treat highly contagious patients. The MRO was commissioned by Germany's Federal Foreign Office to convert an Airbus A340 into a special evacuation aircraft during the Ebola epidemic in 2014.

In addition to providing space for a patient transport isolation unit, the A340 required special adaptations to isolate crew, prevent contamination and supply power to systems for in-

well as two exterior tents to serve as buffers for entering and exiting the isolation tent. To prevent contamination in the event of a sudden pressure loss, LHT integrated flaps into the isolation tent structure that could open and safely collect the air. It also installed electrical connections and a special communication system for aircraft crew and medical staff.

An integral part of the design was LHT's patient transport unit (PTU), which provides the necessary underlying infrastructure and medical equipment needed to transport intensive care patients on a large aircraft. LHT says it can be installed within minutes using seat-track adapters in any aircraft, and it is small and

Airtight tents protect the rest of the aircraft from contagious patients in LHT's Airbus A340 evacuation aircraft.

Beechcraft King Air to the Bombardier Q400 into medevac formats, points out that these try to replicate on-the-ground environments as closely as possible in the air.

"Creating the medical space requires an intelligent approach, some ingenuity and, on occasion, a bit of imagination," says Sean Gillespie, executive vice president for operations at Flying Colours. He notes that in addition to forming close relationships with medical equipment suppliers, the MRO tries to maximize the use of space and

to ensure that the equipment can be safely and securely installed. “Space and weight have to be taken into consideration, as well as the needs of attending clinicians so they have the best possible environment to deliver the best possible care. We need to consider patient access and egress—you don’t want to be lifting a critically ill patient over a set of obstacles,” he explains.

At the basic level, Gillespie says medevac installations incorporate stretcher beds, medical oxygen supply and seating for passengers and medical staff. More advanced, dedicated air ambulances are outfitted with full emergency equipment offering life-support systems for critical medical emergencies as well as soundproofing to reduce noise levels in the cabin. To incorporate specialized components such as these, Flying Colours also needs to obtain the appropriate supplemental type certificates (STC).

“This takes experience and can be extremely complicated, as the equipment will often incorporate complex electrical components, unusual materials that are not generally found in the aviation environment or specific items not normally used on aircraft, which means we have to do a lot of testing to make sure the materials can be validated for aviation use,” Gillespie says.

Flying Colours anticipates that it will receive more medevac-related requests after COVID-19—particularly for multipurpose interiors that can be easily swapped out as needed. One

such example is a project the MRO began for aerial firefighting provider Conair Group in 2018, for which it is modifying six Q400MR aircraft with interchangeable interiors for passenger, cargo, combi-transport and medevac modes. The aircraft remain in cargo mode while firefighting operations take place, but the side wall fittings and alignment are designed so the custom interiors can be quickly changed as needed.

“The design of the interior change-out is influenced by the need to be able to make the swap-out of the components within a short period of time,” explains Gillespie, noting that Flying Colours aimed for a design that could be changed out in 6 hr. or less by a team of 6-8 people. “This was the initial request, and we even timed it with stopwatches to ensure we met the needs as requested.”

One company offering a unique take on transforming cargo aircraft interiors is Knight Aerospace, which designs, manufactures and installs custom modules that can roll on and off and then be locked into an aircraft’s cargo handling system. The San Antonio-based company describes the modules as being similar to “building an aircraft inside of an aircraft.”

“We’re giving our customers the ability to transform their cargo aircraft into multi-use aircraft. Having an aircraft on the ground is expensive, so we’re giving them the ability to transport high-level individuals,



FLYING COLOURS CORP

carry out medical missions and do various operations so they don’t have an aircraft on the ground,” says Michael Knight, vice president for sales and marketing.

The company recently began production of its universal patient module and aero-medical bio-containment module (ABCM), which build on the VIP modules it has already been producing for government customers worldwide. Typically designed for cargo aircraft such as the Lockheed C-130 or Airbus A400M, Knight Aerospace’s modules have been produced with a heavy focus on elements such as acoustic and vibrational treatment, air quality and lighting to make traveling inside feel more like a commercial aircraft—and as close to a hospital setting as possible.

“One of the things that we bring to the table that’s very unique is pressurization. We can either pressurize our modules for negative pressure or positive pressure,

One of Knight Aerospace’s custom interior modules was loaded onto a Lockheed C-130J Super Hercules.

depending on the kinds of patients that we’re trying to transport, so this starts helping you in things like contagion,” says Bianca Rhodes, president and CEO of Knight Aerospace. “For instance, if you’re transporting a burn

KNIGHT AEROSPACE





A Bombardier Challenger 650 medevac interior Flying Colours completed for Swiss Air-Rescue Rega.

gious diseases such as COVID-19, the concern becomes more about preventing contamination from reaching crew. For example, Rhodes notes that during the Ebola outbreak, aircraft used to transport patients needed to be grounded afterward for decontamination.

“Separating the air crew from the patient and the medical crew is huge. You can take this structure, roll it in, lock it into the aircraft in an hour, fly your mission, come back, roll it off and you’ve not exposed the aircraft or the air crew to any of that,” says Rhodes, noting that the interior can be further enhanced to separate medical crew from patients.

To help design the medical modules, Knight Aerospace’s engineers studied operating rooms, ambulances and air medical helicopters to understand the nuances of transporting patients. The modules feature 30 air changes an hour, electrical components in the

ceiling so wires do not become obstacles, and a sink component with hot water, refrigeration and a safe for controlled medications. Rhodes says other unique elements include horizontal and vertical railings for equipment storage and intensive care unit (ICU) beds that come out of the wall to allow full access to the patient.

The medical modules can also be taken off a cargo aircraft and operated on the ground once hooked up to a power source, so they could potentially serve as remote clinics or ICUs in areas with less developed medical facilities. Knight Aerospace expects the solution to have appeal for both military and international nongovernment organizations.

Since the COVID-19 outbreak, Rhodes says Knight Aerospace has worked with its initial customer for the universal patient module to expedite production and has since received several other requests, primarily from the air forces of various countries. It has also sold its first ABCM, which it expects to complete soon. ☒

patient, you want as few contaminants in the atmosphere as possible because infection is probably the biggest issue for a burn patient.”

Conversely, when it comes to conta-

Medical aircraft require electrical connections for specialized equipment such as life-support systems.



LUFTHANSA TECHNIK

Engine MRO Plagued by Low Demand and Rising Retirements

Availability of spare engines with life left will save airlines money

Sean Broderick **Washington**

The collapse in airline passenger demand quickly found its way into the engine-overhaul world, with inductions dropping 50% or more in April in some major networks. Engine MRO will recover, but its climb will be complicated by several factors introduced by the sudden glut of airplanes that airlines find on their hands.

First, the good news: Even factoring in the current-generation Leap and PW1000 families, most narrowbody engines are still approaching their prime aftermarket-revenue years. CFM joint-venture partners Safran and GE note that 57% of the combined CFM56-5B and -7B fleet is less than 10 years old, and 62% of it has had one shop visit or none at all.

As traffic recovers, narrowbodies are expected to lead the way as more domestic travel and suppressed long-haul demand maintains pressure on widebodies. This bodes well not just for CFM but also Pratt & Whitney and MTU as well, which lean heavily on the V2500s and PW100G-JMs that share the Airbus A320ceo and A320neo fleets, respectively, with CFM.

Most of those engines are on long-term agreements. But if aircraft are not flying, that revenue stream slows. GE says its long-term revenue, most of it generated by the CFM product line, could be off by 50% this quarter. Pratt & Whitney parent Raytheon Technologies saw engine inductions plummet 70% in April after what was a largely routine first quarter.

For current-generation platforms that power the most prominent in-production models, recovery will be linked to hours and cycles. Operators of Airbus A220s, A320neos, A350s, Boeing 787s, and—once they are cleared to return—the all-Leap-1B-powered 737 MAX fleet, will be turning to their old standbys, the engine OEMs, for support. But MRO demand from the

rest of the fleet could be reshaped by a surge in retirements.

Consultancy AeroDynamic Advisory analyzed the 15,000 aircraft parked as of early May due to the pandemic-related capacity pull-down. Its conclusion? Nearly a third of them, or 4,600 aircraft, are at least 15 years old and many may never return. But engines with green time—life-limited parts with cycles remaining or acceptable exhaust gas temperature margins—

ments, we believe airlines and lessors will have more options regarding engine green time, which could initially limit the uptick in engine MRO activity,” says Canaccord Genuity analyst Ken Herbert. “We continue to view the engine aftermarket as one of the strongest over the cycle . . . but the potential availability of used material can have a direct impact on both component and engine OEMs and spare parts sales into the aftermarket.”

Projected Aircraft Retirements, 2020

	Narrowbody	Widebody	Regional Jet	Turboprop	Totals
SCHEDULED	210	89	70	84	453
EARLY	821	443	507	424	2,195

Source: Oliver Wyman

are candidates to be cycled back into the fleet.

A similar analysis by Oliver Wyman identified 2,200 aircraft parked during the pandemic that are not likely to return, with the largest chunk, 37%, being narrowbodies. Those retirements will free up about 4,000 engines with at least 90 days of life remaining, says Derek Costanza, a partner at the firm. Most of the available engines will have 1-2 years of life in them before they need overhauls, but some will have up to four years, Costanza says. The combined green-time pool is expected to reduce engine restoration visits 9% for the remainder of 2020 and 7% next year—the equivalent of \$1.75 billion in engine overhaul expenses.

The relatively short-lived relief likely means that green-time usage will not eat into MRO revenues for more than a couple of years as demand ramps back up. But its depth will be dictated by both the number and types of aircraft retired. Another factor will be the imminent jump in available used serviceable material, which will lessen reliance on the new-parts market.

“If we do in fact see a surge in retire-

Before the pandemic hit, the aftermarket was pegged to post year-over-year growth somewhere in the high single-digits, at least. Aviation Week’s Commercial Fleet & MRO Forecast had the full market generating \$82.5 billion for 2020, with about 40% coming from engine work.

Now such estimates vary widely, all because the pace of recovery is impossible to project. Canaccord says a steady rise in activity in the second half of the year could limit the full-year decline to 25%, with the most significant dip coming during the current quarter. Raytheon says its commercial aftermarket business, which includes Pratt and Collins Aerospace, will be down closer to 50%.

MTU, which arguably has the broadest visibility among manufacturers into the engine MRO market due to its risk-sharing stakes across many platforms, is not looking beyond what it can see.

“You don’t even know exactly how many shop visits you’re going to have in quarter two,” says MTU CEO Reiner Winkler, conveying the challenge of offering even updated full-year guidance. “It’s far too early to speculate.”

MRO Workforce Trends

Study findings reveal impact of labor shortage and MRO outlook

Lee Ann Shay **Chicago**

The aviation aftermarket was already bracing for a market downturn in March, when the COVID-19 pandemic's impact was starting to spread rapidly around the world. In a survey conducted by the Aviation Week Network and Bank of America from March 6 to April 1, 41% of respondents said their business had declined over the prior six months, although 37% had not seen a significant change. When asked to project business conditions for the next six months, however, 48% of respondents predicted less work, and only 30% expected no significant change (see chart at top left below).

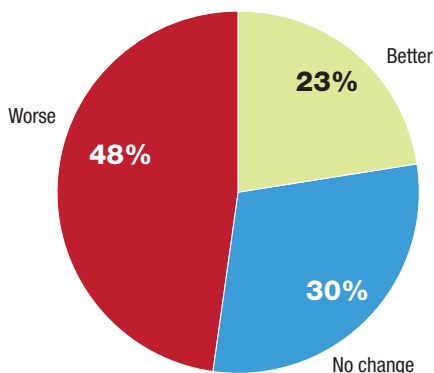
Given the steep decline in airline traffic since the survey was conducted, those numbers would probably be even more pessimistic now.

"The most negative groups were PMA (54% expected worse conditions) and OEM-owned MROs (53% expected worse conditions)," Bank of America's analysis concluded.

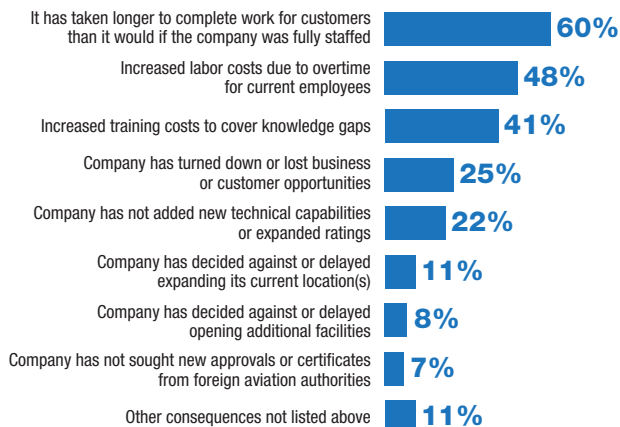
The MRO industry was feeling pricing pressure at the time of the survey compared to the previous six months—33% were already cutting prices, and 38% predicted they would in the next six months. While about half were not planning pricing changes at the time of the survey compared to six months prior, that number decreases slightly when considering the rest of the year (see chart at lower left below).

When it comes to hiring technical staff, it should not be surprising that the vast majority (77%) had been having a

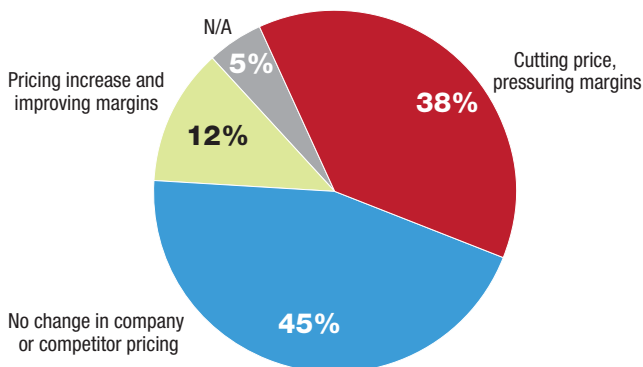
In the next six months, how would you describe the market outlook in your industry?



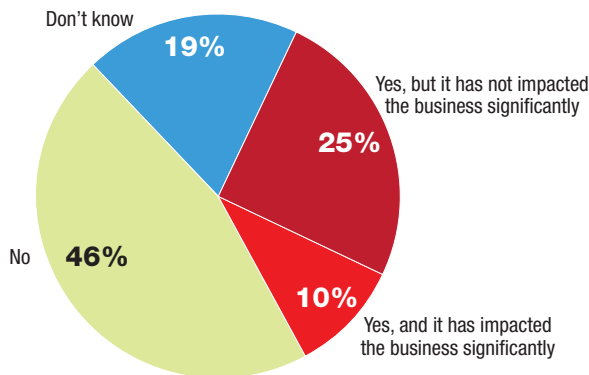
What have been the consequences of your difficulties in filling technical positions?



In the next six months, how would you describe your expectations regarding the pricing environment?



Has your company had difficulty filling MRO management positions?



Sources: Aviation Week Network/BoA Global Research

hard time finding the right people, causing work to take longer and labor costs to be higher (see chart at bottom right of preceding page).

About half (46%) of employers were seeing a shift in required skills due to the digitalization of aircraft and tools such as predictive maintenance, and 41% were increasing training to cover knowledge gaps in general. However, while 54% said potential employees have sufficient skill sets, there just aren't enough of those people to hire.

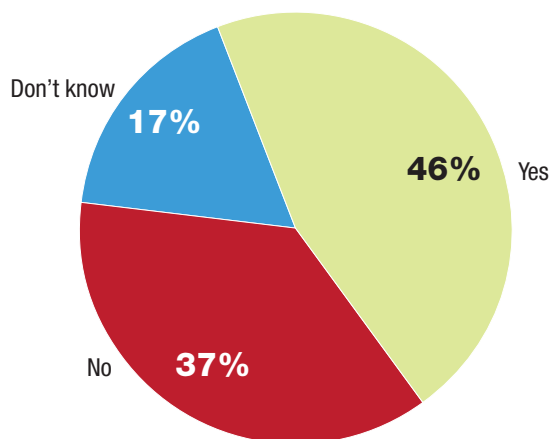
Of the 35% of respondents who said it is difficult to fill MRO management positions, only 10% said that is affecting their business significantly.

The estimated average proportion of respondents' workforces that comprise contract labor is 16.2%.

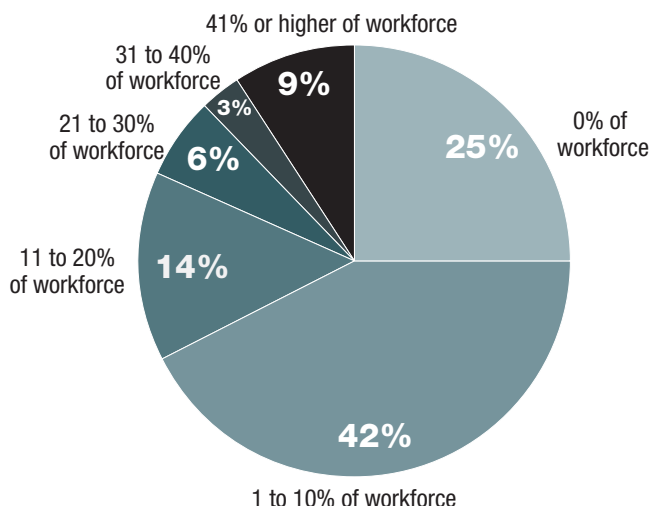
Respondents say about 15% of current staff will reach retirement age in the next five years on average. Given that many companies have offered voluntary leave programs and others have furloughed workers during the pandemic, the workforce composition post-pandemic could very well be different.

Respondents to the survey came from a mix of the industry—independent MROs, OEM-owned MROs, airline MROs, and parts manufacturers and distributors. About 70% of respondents work for companies headquartered in the U.S. 🇺🇸

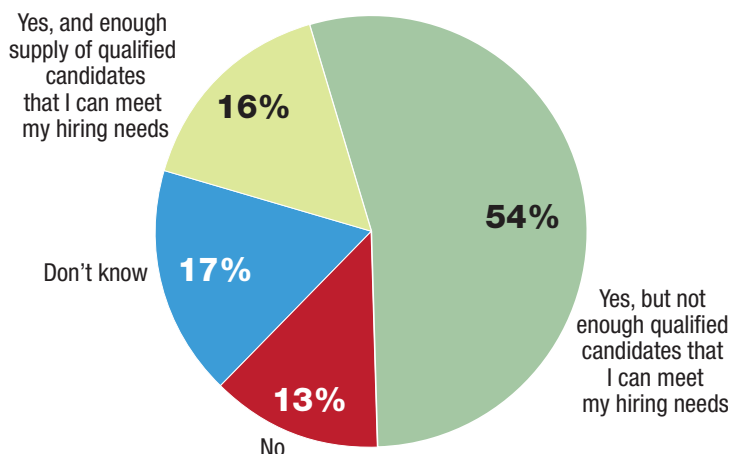
Are you seeing changes in the required skill sets for employees due to digitalization/the use of big data?



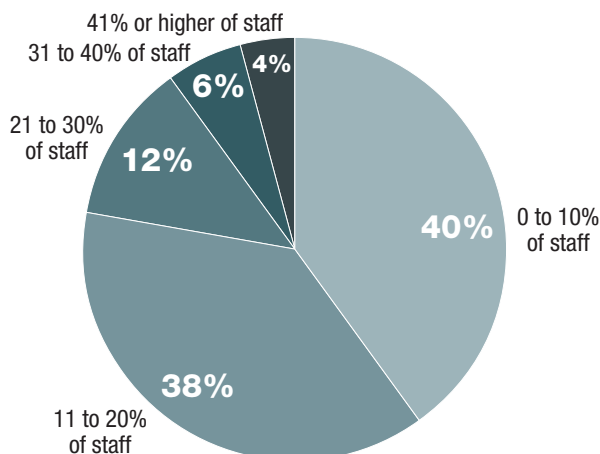
What percentage of your workforce is contract labor?



Does the labor pool you are hiring from have potential employees with sufficient skill sets?



What percentage of your staff is entering retirement age in the next five years?



Sources: Aviation Week Network/BoA Global Research

Additive Advantages

The COVID-19 crisis highlights the value of additive manufacturing for aerospace and MRO

Lindsay Bjerregaard **Chicago**

As aerospace OEMs face production cuts, layoffs and liquidity challenges in the midst of the novel coronavirus crisis, the suffering supply chain may force the industry to move more toward innovative solutions such as additive manufacturing (AM) to meet demand for aircraft components and tooling.

application engineer at Fast Radius.

"It's really offered an interesting alternative without the need to convert the entire manufacturing line over to an entirely new process that it hasn't been equipped for," says Schroeder. "Additive allows for a much quicker digital alternative to cutting an injection molding tool or setting up a line

broadly to organizations that haven't started down that path, was that the technology can be effectively used within aerospace to effect rapid change, which is exactly what you need when you're looking at the challenges an MRO environment experiences."

Paula Hay, vice president for advanced manufacturing engineering and technology at Collins Aerospace, says additive has demonstrated its ability to adapt quickly to the current environment, but that does not mean it will be fast-tracked everywhere.

"Because there is so much uncertainty and slowdown in aviation right now, it's not clear whether or not orga-



These face shields were additively manufactured using the Stratasys F900 printer in response to the COVID-19 crisis.

Chicago-based AM specialist Fast Radius is finding that additive's ability to ramp up production quickly in uncertain times makes it a valuable piece of the supply chain—as evidenced by its role in increased production of medical equipment such as face shields and parts for ventilators.

"That's really kind of proven out over the past month or so here, and similarly we're seeing the same situation with other customers such as those in aerospace or large industry where, especially earlier this year when the virus was over in the [Asia-Pacific] region, they were experiencing supply shortages. We were able to meet some of those demands by converting some of those products to additive to be able to ensure that they were still able to operate their factories," says Matt Schroeder, senior

for stamping or any other traditional manufacturing technology where it just takes a very long time to ramp that up."

Scott Sevcik, vice president for the aerospace business segment at Stratasys, notes that U.S. aerospace companies with 3D-printing expertise were called upon by the government during the COVID-19 crisis to help produce medical equipment for the Federal Emergency Management Agency, and they were able to deliver it within just a few days.

"An industry that's often viewed as stodgy and cumbersome really turned on a dime, and they could do it because they've built up a level of expertise with industrial 3D printing and equipment," says Sevcik. "I think what it demonstrated very loudly within those organizations, and hopefully even more

nizations will invest the resources to advance additive or reserve them for running daily operations," says Hay. "If we do see an uptick in new adoptions, it will most likely be first in the area of tools and then spread more to parts."

Sevcik notes that tooling remains a growth area within additive, and at Collins—which is in the process of creating several centers of excellence for additive—development efforts have started around directed-energy deposition to both repair damaged parts and build large-scale parts and tooling.

Additive materials themselves are also an area where both Stratasys and Fast Radius see innovation happening within aerospace. Fast Radius points to new polymer materials coming to market that are flame-, smoke- and toxicity-rated. Stratasys recently released



COLLINS AEROSPACE

Collins says this additively manufactured thrust reverser cascade array is the largest additively manufactured structural nacelle part. It will be ready for flight tests on business jets later this year.

its Antero material, which can “withstand oils, fuels and hydrocarbons better than any plastic that you’d typically see in 3D printing,” Sevcik says.

In recent projects with the U.S. Air Force, Stratasys has focused on innovations such as colored materials and printed textures to reduce post-processing, meaning parts can go straight from the 3D printer to aircraft. Fast Radius’ Schroeder notes that AM color technology also enables printing of elements such as logos, serial numbers and QR codes directly onto tools and parts. This can enable “true traceability across the entire product life cycle, where that QR code can be specific to that single product, and you can trace [it] all the way back to the machine that [it] was manufactured on.” Innovations like this could allow customers to scan QR codes to quickly order replacement parts or even have implications for blockchain record-keeping systems.

Schroeder believes that some 3D-printing innovations taken from other industries—such as automotive or consumer goods—could also have applications for aerospace. Fast Radius has already created 3D-printed elec-

trical connector parts for automotive uses and is now working with a large aerospace OEM that manufactures electrical components for aircraft.

Schroeder says the 3D-printed electrical connectors can be customized

for testing in the initial stages, but then also as either a bridge to tooling—where it makes sense to make the first, say, 10,000 using additive before converting over to traditional methods. Or, in some cases, we’re actually able to achieve a performance improvement by using additive, and, if it makes sense, to produce using additive throughout the entire life of the program,” he adds.

One innovation from the consumer goods industry where Schroeder says adaptation for aviation uses could also be possible is the implementation of lattice technology, which entails engineered structures able to dampen vibration or impact. “A lot of the work that we’re doing in those spaces is to really understand how these structures are architected, and how to design these structures is then also being carried over to aerospace, where you can reduce the vibration within a system and you can reduce, in some cases, impact,” he says.

Reducing vibration is a key focus area for the engineering of next-generation electric vertical-takeoff-and-landing aircraft, so this technology could prove useful in their designs. Aircraft used for medical transport also seek to reduce vibration to create a hospital-like environment in the air (see page MRO17), so this could also be advantageous in today’s COVID-19 environment. ☺



FAST RADIUS

Logos, serial numbers and QR codes can be 3D-printed directly onto tools and parts for easier traceability.

based on a customer’s requirements. “For instance, if there’s a very low-volume application with new electric flying aircraft, we can very quickly design a connector that’s able to meet that application without the need for any capital investment or the need to cut a tool, so we can very quickly ramp up those connectors in the product development cycles,” he says.

“Often we’ll see customers use it

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GE90 Outlook

An overview of airworthiness directives affecting the GE90



JOE PERSAMATION/NET

Frank Jackman Washington

Fallout from the October uncontained failure of a GE90-115B engine on a Thai Airways Boeing 777-300ER continues.

On May 12, the FAA issued another airworthiness directive (AD) related to the event, this one requiring initial and repetitive ultrasonic inspections of certain interstage high-pressure turbine (HPT) rotor seals installed on GE90-110B1 and -115B engines. Depending on the inspection results, the AD also calls for removal and replacement of the HPT rotor seal.

The latest AD, effective May 27, also requires the removal of the interstage HPT rotor seal at the next engine shop visit.

The ADs are targeted at a group of 16 engines that are operated by just two carriers. None of the engines is installed on U.S.-registered aircraft, according to the FAA.

A spokesman for GE said the company is limited in what it can say because the AD is part of an ongoing investigation but that the engine-maker is working closely with its customers and regulatory authorities to inspect or replace HPT interstage seals on a "limited population" of -115Bs.

On Oct. 20, the Thai Airways 777 was taking off from Bangkok on a scheduled flight to Zurich when the HPT failed, and the crew conducted

a low-speed rejected takeoff. Debris from the uncontained failure damaged the aircraft's fuselage and the other engine. The root cause of the failure is still under investigation.

In the days after the failure, the FAA issued an emergency AD and later followed up with a final ruling requiring removal of the interstage seal from eight specific -115B engines. In January, the FAA issued a second emergency AD (2020-01-55) extending the seal removal requirement to select GE90-110B1 engines, bringing the number of engines involved to 16.

In January, GE issued a service bulletin to -115B and -110B1 operators on how to do an on-wing ultrasonic inspection at the air holes of the interstage HPT rotor seal. The FAA cited the GE service bulletin in the latest AD.

The first GE90-powered 777 completed its maiden flight in February 1995. Since entering service, the engine family has accumulated more than 95 million flight hours and 13 million cycles, according to the manufacturer's data. The -115B has a dispatch reliability rate of 99.97% and an engine-caused inflight shutdown rate of 0.0004, the OEM says.

The Aviation Week Network's Fleet Discovery database shows that about 200 of the 1,200 Boeing 777 aircraft fleet are in long-term storage, with

A Thai Airways 777-300ER suffered a GE90 engine failure last October.

about 340 in parked reserve (idled) or parked status.

In 2013, two GE90 engines suffered inflight shutdowns in just three months, resulting in an emergency AD in May 2013 for -110B1s and -115Bs equipped with particular transfer gearbox assembly (TGB) radial gearshafts. The assemblies targeted had been manufactured by a GE supplier during a six-month period between September 2012 and March 2013.

The AD prohibited an aircraft from being operated if more than one installed engine had an affected TGB radial gearshaft. The final AD revised the applicability of the directive to include -76B, -77B, -85B, -90B, -94B and -113B engine models. The AD also required installing a new TGB radial gearshaft.

Another series of ADs was issued following the September 2015 uncontained failure of a GE90-85B engine on a British Airways 777-200ER. The engine failed and caught fire during the takeoff roll on a flight from Las Vegas McCarran International Airport. The crew rejected the takeoff, and the airplane was evacuated on the runway.

A subsequent investigation found the engine had failed because of a fatigue crack in the high-pressure com-

pressor (HPC) stage 8 disk, according to the NTSB. The board said the HPC stage 8-10 spool failed due to a sustained-peak low-cycle fatigue crack, but the cause of the crack's initiation could not be determined.

In January 2016, the FAA issued an AD requiring eddy current or ultrasonic inspections of the HPC stage 8-10 spool and the removal of failed parts. In April 2017, the FAA issued an AD requiring eddy current inspection of the spool at each shop visit for all of the affected engines and repetitive on-wing eddy current or ultrasonic inspections for certain affected engines prior to shop visits.

A product quality escape at a GE supplier prompted the FAA to issue AD 2018-20-22 in October 2018 requiring the removal and replacement of certain combustion cases from GE90-110B1, -113B and -115B engines. According to the AD, AECC Aero Science and Technology Co. Ltd. had performed certain welds on newly manufactured components to correct errors introduced



MTU AERO ENGINES

The GE90 engine family has accumulated more than 95 million flight hours.

during the manufacturing process, but the welds were not approved by GE or the FAA. The combustion cases are life-limited parts, and the unapproved welds reduced the material capability of the cases, the FAA said.

Since some airlines, including Delta

Air Lines, have recently announced plans to retire their 777s, aftermarket demand for the GE90 will most likely decrease because of the COVID-19 pandemic unless those aircraft are picked up by other carriers or converted into freighters. 🛩️

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Remote-Collaboration Tools

Lindsay Bjerregaard **Chicago**

1. Hands-Free Guidance

Company: RealWear

Specifications: RealWear's HMT Platform for remote collaboration consists of a hands-free, voice-guided headset with a high-definition camera tailored for industrial use cases. In addition to enabling two-way video calling between workers in the field and remote experts, the platform gives workers access to technical manuals and documents, step-by-step instructions and internet of things data visualization. The device is capable of pairing with any Android app that has been optimized for hands-free voice control. RealWear says the HMT Platform is "flying off the shelf" right now, thanks to its recent integration with Microsoft Teams.
marketplace.aviationweek.com/company/realwear



2. Remote Expertise

Company: Testia

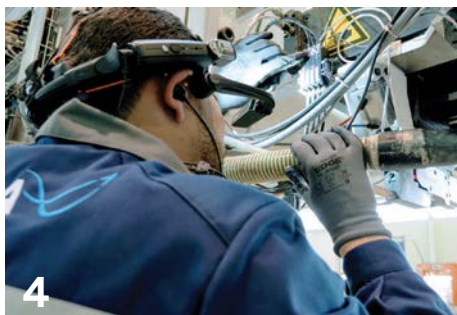
Specifications: Testia Remote Assistance is a browser-based application for real-time, expert quality assurance on remote tasks such as maintenance inspections or repairs. Technicians on site are linked to a remote expert via live video communication, and the expert can then draw on the screen via the tool's integrated whiteboard feature or take control of the settings and results from measurement devices or computers used on site. The tool is device-agnostic and can run on smartphones, computers and wearables, with the ability to store and share data via the cloud.
marketplace.aviationweek.com/company/testia-airbus-company



3. Automated Aircraft Inspections

Company: Donecle

Specifications: Donecle's drones can be used for visual inspection of entire aircraft exteriors, combining high-resolution images with automated defect detection and report generation. According to Donecle, its solution inspects aircraft



10 times faster than current inspection methods while reducing safety concerns for technicians working at height. The company's secure cloud platform enables immediate upload and sharing of inspection data to give customers an objective view of an aircraft's structural condition as well as access to the digital history of inspections for potential predictive maintenance use cases.

marketplace.aviationweek.com/company/donecle

4. Long-Distance Problem-Solving

Company: Expert Teleportation

Specifications: Expert Teleportation is a hands-free remote-collaboration system that pairs smart glasses with software to connect technicians with remote experts. Technicians completing tasks such as inspections can use the system to contact an expert and share what they are seeing to get help in solving problems. Expert Teleportation is working to integrate new functionality into the system, including automated reporting using machine learning and a maintenance application to provide step-by-step instructions.
marketplace.aviationweek.com/company/expert-teleportation

Go to MROLinks.com for more information.



5. Remote Borescope Inspections

Company: Safran

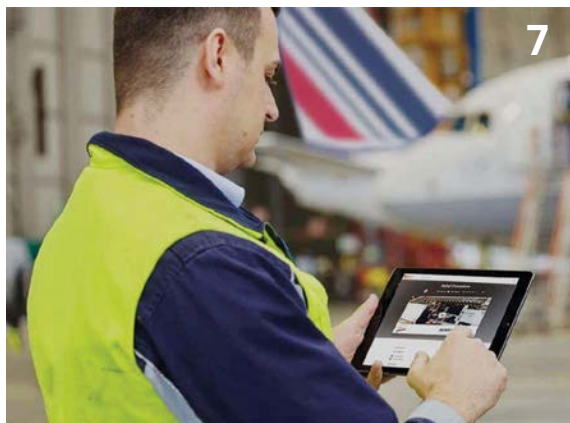
Specifications: Safran's B.Slide is a remote borescope-inspection service to enable both on-the-job training of technicians working on Safran engines and provide expert advice during borescope engine inspections. Technicians are able to share live images of borescope inspections that both parties can zoom in on and consult while conducting a face-to-face video call. The system comes with accessories to connect to and share borescope images with live experts from Safran as well as an interactive web platform and iOS app that features an automated checklist and inspection report generation tool.

marketplace.aviationweek.com/company/safran

6. Digitized Work Instructions

Company: Atheer

Specifications: Atheer's Augmented Reality Management Platform enables teams to collaborate remotely using video assistance from remote experts and digitized work instructions, which the company says can



provide efficiencies for aircraft and engine inspections. Atheer says the platform helps companies deliver on-the-job training faster and more broadly across multiple locations, providing a 20-50% reduction in the cost of training a distributed workforce. The company also says the platform can enable better supply chain collaboration for the maintenance and repair of aircraft components.

marketplace.aviationweek.com/company/atheer

7. DIY Interactive Video Tutorials

Company: Speech

Specifications: A knowledge-sharing platform from Speech enables MRO technicians in the field to capture interactive digital work instructions from their locations and share them with team members worldwide. The platform blends audio, video, text documents, images and hyperlinks to allow MRO technicians to quickly create, share and view tutorials on a tablet or smartphone. Speech promotes the platform as beneficial for both onboarding new workers and enabling technicians in any location to share step-by-step video instructions with colleagues worldwide.

marketplace.aviationweek.com/company/speechme

8. Guided Maintenance

Company: Librestream

Specifications: Librestream's Onsign mobile collaboration platform enables technicians to work remotely with experts and customers to perform guided maintenance tasks, conduct remote inspections, and witness and certify tests. The augmented reality platform features software capabilities such as analytics, capture of content for training and audits, data visualization, digital work instructions and more, as well as optional accessories such as the Onsign Cube thermal wearable.

marketplace.aviationweek.com/company/librestream-technologies-inc

Go to MROLinks.com for more information.



By **PAUL OLIVER**

Paul Oliver has been in customer support roles at Airbus since 2002 and has led North American customer service since 2016.

AIRBUS

MRO's New Normal

Finding the way forward from parked to flying aircraft

Everything about the coronavirus pandemic has been dramatic: the speed at which air traffic slowed, the huge numbers of aircraft that were parked, and the resulting hit to airline revenues. As many as 15,000 aircraft have been put into some form of parking, storage or early retirement.

Early in the crisis, the question of how much parking, storage and end-of-life maintenance was being planned for the fleet gave an indication of how long airline executives expected the pandemic to last. Some were even requesting minimum or curtailed work packages, not just because of the unprecedented volume of aircraft being parked but also because they were looking to “keep their planes warm” in expectation of a quick rebound. Airbus reacted swiftly by adapting the type and amount of maintenance needed for various durations of parking, thereby optimizing maintenance costs, and by creating a geospatial “Parking Management” app based on its digital Skywise platform.

The big question quickly became: How long will parking be required? On the one hand, there is an imperative to preserve cash and ground aircraft. On the other hand, airline bosses wanted to limit the time and effort needed to get the fleet flying again once the worst of the crisis is over. As the true size and scale of this pandemic continues to unfold, it may become evident that some of the early decisions made about short-term aircraft parking were premature.

It is also clear that less efficient aircraft will be the first to be retired. For example, Delta Air Lines an-

nounced very early on that it would retire its entire MD-88 and MD-90 fleets. Furthermore, as airline executives scrambled to decide which aircraft would be parked and for how long, the playing field shifted again with rapidly falling fuel prices.

The word being used most often about aircraft mix these days is “adaptation.” Virtually all airlines have declared they will emerge with smaller and more efficient fleets—with fewer types and more fuel-efficient planes. American Airlines recently said it will retire Airbus A330-300s, Boeing 757s and 767s, Bombardier CRJ200s and

Embraer 190s. Shortly thereafter, Delta declared that its entire fleet of Boeing 777s will not return to service, despite recently investing heavily in new interiors for many of them. It is also a clear signal that long-haul traffic will be slower to recover.

If there is a small silver lining here, it is the unexpected opportunity for bundling maintenance. In many cases, abrupt parking meant both aircraft and mechanics were collocated. This presents a rare chance to embody mods in one shot without having to compete with network planners for precious ground time, as is the case during so-called “normal” times. One U.S. operator is working at full pace, performing a cabin retrofit for a sizable portion of its Airbus

fleet. Another told me it is taking full advantage of this period for multiple modifications and tidying up aircraft to the extent of even being able to “clean the seat tracks with a toothbrush” if the crisis continues. Doing maintenance is good, as long as it does not consume too much cash and provided it goes into aircraft that will eventually fly again.

After the crisis, the “new normal” for airlines seems destined to be operating with less liquidity and a smaller workforce, resulting in demand for off-balance-sheet approaches for long-term spares and maintenance. The surge in availability of used serviceable material that will accompany early retirements of aircraft will create a much higher supply than demand in that market.

How will MROs fare in this new environment? Traditionally, in downturns the MRO sector is hit as hard as the airlines. Line activities dry up quickly as routes and frequencies are shed, and heavy maintenance is deferred as aircraft requiring major MRO events are preferentially parked. Meanwhile, engines and components are harvested from owned-asset aircraft, resulting in less work for engine MROs and OEMs, which rely heavily on that aftermarket for services business.

For the MROs able to adapt quickly, there should be rich pickings as the crisis ebbs. Carriers with ultra-low costs per available seat-mile are betting on a fast rebound when it finally happens. MROs that can match the cost structure of those carriers will be best placed to benefit from the upturn. Successful will be the agile MROs that adapt to the need for bundled services incorporating a wide spectrum of activities and can add extra value—as well as those that act as true partners in helping carriers with their recovery efforts.

The new normal for MROs will be a very different place, with consolidation likely, highly competitive bundled offerings and greater levels of partnership. The only remaining question is: When will all of this start to take off again? ☘

For the MROs able to adapt quickly, there should be rich pickings as the crisis ebbs.

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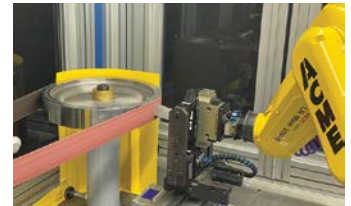
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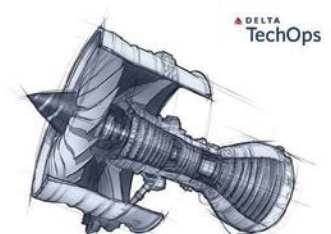
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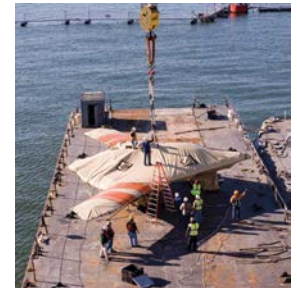
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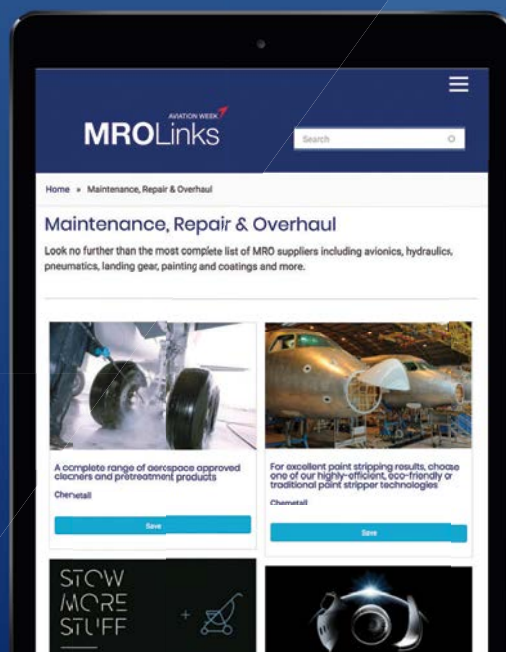
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of the R-37 missile (AA-X-13), which never entered service. The R-37 is the main armament of the Mikoyan MiG-31 Foxhound C, which potentially gives it a standoff range to shoot down support aircraft such as tankers and airborne early-warning platforms—while still keeping the aircraft out of range of the fighters protecting their targets. The R-37M would also be used to engage bombers carrying cruise missiles as well as the projectiles themselves.

Barrie says recent investments in Russian air-to-air missile capabilities may even have been partly spurred on by Chinese developments, not to mention concerns that Moscow could lose market share to Chinese air-to-air missiles in the export arena over the coming years.

China's technological edge may prompt some nations to undertake integration of Chinese missiles on their fighters or cause others simply to purchase Chinese combat aircraft such as the Chengdu JF-17 Thunder, developed in conjunction with Pakistan. The JF-17 has already secured orders from Myanmar and Nigeria.

During the 1990s, China's air-to-air missile inventory consisted of weapons purchased from Russia, or clones of them, and other Western missiles such as the U.S. AIM-9 Sidewinder or the French Matra Magic. Beijing also secured a large number of the Python 3 air-to-air missiles from Israel. But China's purchase of Sukhoi Su-27 Flankers from Russia and access to technology from Israel likely helped pave the way to produce the first indigenous Chinese beyond-visual-range missile: the PL-12, also called the SD-10 for the export market. The missile in its original form may have used some Russian technology in the seeker, actuators and data link, Barrie says, while an upgraded version is introducing more indigenous components.

"The PL-12 allowed Chinese industry to get its head around what a modern air-to-air missile looked like," Barrie says. "Now, with much of the development in-house, there is very little evidence of external support."

Since the advent of PL-12, Beijing's road map of development has expanded. The PL-10, a dogfighting missile, is a weapon that experts suggest could have reach beyond the within-visual-range arena similar to that of the MBDA Advanced Short-Range Air-to-Air Missile and the South African A-Darter.

And there is the long-range PL-XX, possibly the PL-17 weapon, first glimpsed on a People's Liberation Army Air Force J-16 in late 2016, which is essentially a flying telegraph pole designed to hold at-risk assets such as tankers and intelligence-gathering aircraft (*AW&ST*, Dec. 5-25, 2016, p. 31).

Barrie says the PL-XX weapon is likely fitted with an active, electronically scanned array (AESA) seeker and possibly with an IR adjunct to overcome any attempt to jam the weapon with electronic countermeasures in the final moments of the engagement.

Open-source information also suggests China may be exploring ramjet technology, which could provide China with a capability similar to the MBDA Me-

teor. There appear to be multiple design developments in this area, Barrie suggests.

"The Chinese air-to-air missile road map is not that dissimilar to that of the [Soviet Union] during the 1980s," Barrie says. "All of the Soviet Union's 1980s [air-to-air missile] projects suffered lengthy delays or were shelved. The Chinese projects have benefited from two decades of sustained investment."

Nonetheless, the PL-15 remains the weapon of concern, even with the U.S. Air Force pushing the development of the Lockheed Martin AIM-260 as a counter.

Experts think the PL-15, like the PL-17, may have an AESA seeker, although this has not been confirmed, but Barrie notes the weapon has so far been generally associated only with platforms that have AESA radars.

And further developments of PL-15 may be on the way. Like the U.S., China has realized the challenge of squeezing more weaponry into the weapon bays of low-observable fighters, with four PL-15s fitting into the bay of the J-20. But there are hints that Chinese engineers are developing a compressed carriage version of the weapon, notionally called the PL-16, with the same performance as the PL-15.

China is also up-arming fourth-generation fighters. Imagery from China

The PL-15 is equipping China's high-end fighters, including the J-10, J-16 and the stealthy J-20 platforms.

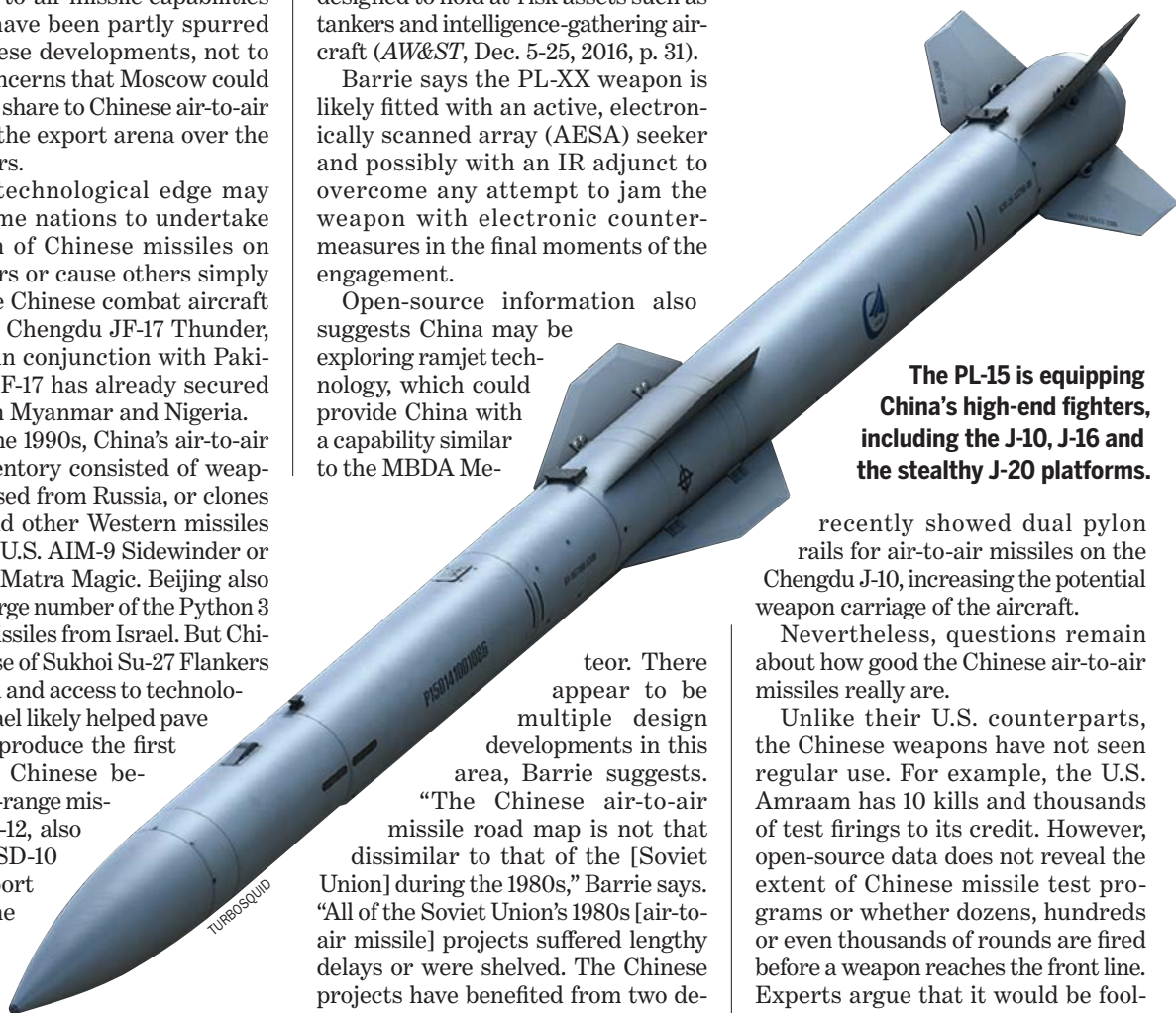
recently showed dual pylon rails for air-to-air missiles on the Chengdu J-10, increasing the potential weapon carriage of the aircraft.

Nevertheless, questions remain about how good the Chinese air-to-air missiles really are.

Unlike their U.S. counterparts, the Chinese weapons have not seen regular use. For example, the U.S. Amraam has 10 kills and thousands of test firings to its credit. However, open-source data does not reveal the extent of Chinese missile test programs or whether dozens, hundreds or even thousands of rounds are fired before a weapon reaches the front line. Experts argue that it would be foolhardy to dismiss their capabilities, particularly given the leaps in technology achieved by Chinese industry over the last two decades.

"These are not just copies," Barrie says. "This is their own work, and they are proud of these developments."

But are the Chinese weapons on par with the very best Western weapons? "Probably not quite," Barrie answers. "But they have closed the gap and will continue to do so." 🌟



Power Change

> NEW F-35 PROPULSION-UPGRADE ROAD MAP IS IN THE WORKS

> PLANNED FUNDING WILL KICK IN BY FISCAL 2023

Steve Trimble Washington and **Guy Norris** Los Angeles

The F-35 Joint Program Office is assembling a proposal for dramatic thrust and fuel-efficiency improvements to the Lockheed Martin fighter's propulsion system. The options under review include upgrading the existing Pratt & Whitney F135 turbofan and revisiting earlier studies, potentially to reengine the fighter in the longer term with advanced adaptive technology to achieve a step change in range and power.

Later this year or in 2021, the Joint Program Office (JPO) will submit the F-35 Propulsion Road Map for 2035, which will propose a recommended timeline for consideration by

burn reduction or 10% thrust improvement. Pratt has previously said the GO-2 package reduced fuel consumption by as much as 20%, with a 15% overall thrust improvement. In 2018, Pratt also proposed another two-step upgrade package tailored for the F-35B variant, increasing the vertical thrust generated by the Rolls-Royce LiftFan by 2.5-5%.

The GO-1 package is focused on upgraded materials, blade-geometry refinements and coating improvements in the high-pressure compressor, turbine and combustor. Elements of the upgrade derive from technology tested since 2013 in the U.S. Navy Fuel Burn Reduction program and from the even earlier Air Force-supported component and engine structural-assessment research (Caesar) initiative for the F119 engine that preceded the F135.

The more ambitious GO-2 package leverages variable-cycle advances developed as part of the more recent Air Force Research Laboratory (AFRL) Adaptive Engine Technology Demonstration (AETD) program. Although Pratt has not detailed which specific elements of AETD these involve, they are likely to include the adaptive fan module tested on an F135 in 2017 at the Air Force's Arnold Engineering Development Complex in Tennessee as well as at the company's facilities in Florida.

AETD was also the forerunner of the Adaptive Engine Transition Program (AETP), which the AFRL launched in 2016 when it awarded contracts worth \$1 billion each to General Electric and Pratt to design, build and test prototype 45,000-lb.-thrust-class adaptive engines. The new centerline designs exploit technology developed under

New upgrades are coming for the F-35 propulsion system.

the earlier Adaptive Versatile Engine Technology and AETD, both of which tested ways of dynamically modulating a third stream of air between the engine's core and bypass duct. The variable-cycle concept enables optimized operations at different flight conditions, saving up to 25% in fuel burn and generating up to 10% extra thrust.

Designated the GE XA100 and Pratt XA101, the two AETP engines are designed to mature adaptive-cycle technology, which is sized for potential application in the F-35 as well as follow-on sixth-generation fighter designs. The initial flight-weight prototypes are expected to be delivered to ground-test teams in 2021. Given typical engine-development timelines, this would suggest they could be certified and ready to enter production within five years.

The internal F-35 Operational Advisory Group endorsed a propulsion-growth study last fall, the JPO spokeswoman confirmed for the first time on June 4. As a result, the Program Management Office (PMO) for the F-35 propulsion system began two separate efforts.

First, the PMO partnered with Naval Air Systems Command's Advance Design Group to analyze growth projections for the weight and thermal requirements of the F-35 air vehicle and mission systems. The working group then evaluated potential upgrade options for the F135, including elements of Pratt's GO-1 and GO-2 proposals.

In parallel, the F135 PMO also "engaged" with the AETP program at AFRL, the JPO spokeswoman said.

The PMO now plans to "develop a technology transition road map that could provide an alternative engine option that capitalizes on the latest technologies that promise both high performance and significant gains in fuel efficiency," the JPO spokeswoman said. ☛



PRATT & WHITNEY

the three U.S. customers as well as international partners, a JPO spokeswoman confirms to Aviation Week.

The JPO will seek funding for the F-35 propulsion upgrade plan in the fiscal 2023 budget, which the Defense Department will unveil in early 2022.

A propulsion upgrade would mark a new phase for the program. The single-engine F-35's impressive power capacity has been a constant throughout the program's nearly 20-year history.

Although the F135 engine is meeting requirements now, the F-35 itself is evolving. The Block 4 follow-on modernization program will introduce a major electronics upgrade in Lot 15 aircraft, which are scheduled for delivery in fiscal 2023. As Block 4 introduces new sensors and weapons on the aircraft, the overall weight of the aircraft is increasing, which creates special problems for the short-takoff-and-vertical-landing F-35B.

Anticipating these growing demands on the propulsion system, Pratt has since 2017 proposed a series of upgrades—known as Growth Options (GO) 1 and 2—to support Block 4 requirements, with GO-1 offering either a 6% fuel

Vintage Racer Concept Suggests Hypersonic Entry for Loitering UAS

- > THE VINTAGE RACER COMPLETED FLIGHT TESTING IN 2019
- > THE PENTAGON TRANSITIONED THE CONCEPT TO THE ARMY FOR FURTHER DEVELOPMENT

Steve Trimble Washington

An inadvertent release indicates the U.S. Army is working on a loitering weapon system that can enter a target area at hypersonic speed, then dispense one or multiple unmanned aircraft systems (UAS) to loiter above the area for 60-90 min.

The concept, named Vintage Racer, previously appeared as only a vague reference in Defense Department bud-

paper visible in the picture carries the headline: “Vintage Racer - Loitering Weapon System (LWS) Overview.”

The raw image provides only a grainy glimpse of the main bullet points, including the terms “Hypersonic Ingress,” “Survivable,” “Time Over Target,” “Multirole” and “Cost Imposition Strategy.”

But a processed version of the image, which was enhanced with Adobe

Photoshop software and obtained by Aviation Week, provides more details of the Vintage Racer concept (see table).

In broad strokes, Vintage Racer appears similar to a long-canceled program that integrated 13 Brilliant Anti-Tank (BAT) submunitions into the Army Tactical Missile System (Atacms) Block II, a new version of the short-range, surface-to-surface missile that was canceled in 2003. The Atacms Block II was designed to enter a target area at or

near hypersonic speeds and release the BAT submunition, which then would use acoustic sensors and an onboard warhead to identify and destroy armored formations.

Unlike the nonloitering BAT submunitions, Vintage Racer releases multiple, winged UAS, according to a graphic visible on the enhanced copy of the briefing paper. The UAS dispenser—possibly an Atacms-like ballistic missile—could deliver the UAS to the target within 5-8 min. No range for Vintage Racer is given, but it could travel nearly 500 km (270 nm) in 5 min. if the average speed during the flight is Mach 5.

Vintage Racer - Loitering Weapon System Overview	
Hypersonic Ingress	
Ingress trajectory	
Low signature/cross-section	
Time Over Target	
Up to 60-90 min. loiter on station	
Multirole	
Engagement and support roles	
Intelligence, surveillance and reconnaissance	
Position, navigation and timing	
Networked communications in a contested environment	
Modular Payload	
Multirole and easily upgraded	
Cost Imposition Strategy	
Inexpensive to deploy	
Target is \$100,000-200,000 per vehicle	
Costly to defeat	

Source: U.S. Army



As Army Secretary Ryan McCarthy (far right) received a briefing at the AUSA in the General Atomics booth on multiple topics, his hand rested on a briefing paper revealing critical new details about the Vintage Racer concept (see table).

get justification documents released in February. The “advanced capability” funded by a Quick Reaction Fund is listed in the budget documents as a “success story” had performed a flight test in 2019 and transitioned to the Army for follow-on development and prototyping.

But the first details about the concept emerged when Aviation Week spotted a picture posted on Army Secretary Ryan McCarthy’s Flickr page on June 6. The picture shows McCarthy receiving a briefing at the General Atomics exhibit booth during the Association of the U.S. Army convention in October 2019. A briefing

Inside the target area, the aircraft could perform “engagement and support roles,” according to the briefing paper. The term “engagement,” along with LWS nomenclature in the title, suggests the UAS would carry a warhead, allowing the aircraft to function like a suicide drone such as the Israel Aerospace Industries Harpy or Aero-Virement Switchblade.

The Vintage Racer’s loitering systems also could perform nonweaponized roles, the paper’s text shows. The sub-bullets under the “Multirole” heading suggest the aircraft could function as an aerial sensor; provide accurate positioning, navigation and timing for other weapons or platforms in the target area; or serve as a communications relay.

The heading for “Cost Imposition Strategy” offers another clue about the type of delivery mechanism involved. The Vintage Racer, the paper says, will be “inexpensive to deploy,” with a target cost of \$100,000-200,000 per vehicle. Such a price rules out more exotic delivery mechanisms such as a new class of intermediate-range, ground-launched hypersonic glide vehicles, which are expected to cost millions of dollars each. Instead, the cost seems aligned with a simpler ballistic missile as the UAS dispenser. ☛

Performance Is Expected To Leap After Australian Jindalee Upgrade

> THE ARRAYS WILL REMAIN, BUT JUST ABOUT ALL THE REST OF THE RADAR SYSTEM WILL BE REPLACED

> THE PROJECT IS DUE TO BE COMPLETED IN 2028

Bradley Perrett Adelaide, Australia

Billed as an upgrade, the work by BAE Systems on Australia's three over-the-horizon radars actually amounts to rebuilding the sensor system, addressing parts obsolescence while providing a jump in performance.

Two years after the program began, the system design review is due in June. Preliminary design review will

the Phase 5 upgrade completed in that year (*AW&ST* Sept. 22, 2014, p. 42). But the program is hardly restricted to replacing old system elements with new ones of similar performance. The work involves new diagnostics, electronic hardware, software and signal processing, the spokesperson says. BAE is working very closely with the government's Defense Science and

include simultaneous multiple-radar operation and various aspects of frequency management at high spatial resolution. Together, this dramatically improves radar utilization, in effect multiplying the radar resource available for mission operations as well as providing operators with higher-fidelity information for more effective radar management."

Frazer formerly worked on these systems at the DSTG. His company is providing radar-design expertise, modeling and test services to the program.

BAE is making some parts at its Adelaide facility, the home of the program and the company's high-frequency radio expertise. "We are very focused on the manufacturing side of things to get cheaper and faster," BAE says. The company mobilized for the program before the government signed the contract.

BAE says higher performance, including lower noise, is required from new parts. The work will improve diagnostics as well: The radars will be better able to monitor their condition, and this will include automatic responses to failures.

The radars currently surveil their fields of view by shifting from one patch of surveilled area to another; each patch is called a tile. After the upgrade, the radars will be able to watch multiple tiles simultaneously. Power management, currently manual, will become automatic.

The interface with operators will be better, becoming more instinctively usable and needing less training. Monitoring of the ionosphere (called sounding) will be improved, along with signal processing. There will be a leap in resolution, the precision with which targets are located and tracked.

Better sensitivity can be assumed, even though BAE will not discuss the matter beyond saying the upgraded radars will be able to deal with small, low-flying targets. Generally declining to discuss the specifics of performance, BAE would not depart from the long-standing RAAF description of minimum target size: a BAE Hawk trainer. A key, unanswered question is whether the sensors will be able to detect and track cruise missiles.

There is potential to extend the daily time period for operation, the spokesperson says. Operation of radars of this kind is severely limited at night, when the ionosphere weakens. ☛

A receiving array of one of the three Jindalee radars in the Australian Outback.



follow in 2021, and detail design review about 12 months later, a BAE spokesperson says. Program completion is scheduled for 2028.

The upgrade is called Joint Project 2025 Phase 6, the name reflecting the utility of the radars' data to all three services, even though the Royal Australian Air Force (RAAF) operates them. Together, they are formally called the Jindalee Over-the-Horizon Radar Network.

The RAAF says the sensors can surveil the air and surface as far as 3,000 km (1,900 mi.) away. They bounce high-frequency radio off the ionosphere, so coverage starts at the 1,000-km range, which is why the radars have been built deep in the Outback. There is a good reason to think they can see farther than 3,000 km because Canberra has never bothered to build extra radars on the coast.

In 2014, the defense department described Phase 6 as basically an effort to address parts obsolescence, following

Technology Group (DSTG), the originator of much of the know-how behind the system.

According to BAE, everything in the radars will be replaced except for their huge transmission and reception arrays and maybe the high-power amplifiers. BAE and Lockheed Martin, which formerly supported two of the radars, are studying whether to propose replacement of the amplifiers, too, since they present some difficulty in maintenance. New amplifiers may be much more powerful, but their full power may not be needed.

The work also will introduce a technology called common aperture receiver array (CARA), says Gordon Frazer, CEO of subcontractor FrazerLab. "Technically very demanding and at the forefront of the innovation in Phase 6, CARA expands the functions that can be performed concurrently by the receiver system," Frazer says in a written reply to Aviation Week questions. "These

BAE SYSTEMS

U.S. Military Turns to Remote Pilot Training

> ARMY PAUSES TO ASSESS TRAINING OPTIONS

> AIR FORCE AND NAVY IMMEDIATELY PIVOT TO REMOTE INSTRUCTION

Lee Hudson Washington

Once the global coronavirus pandemic hit the U.S., the military moved to ramp up remote pilot training options. But it is unclear if the trend will continue after the contagion passes.

Before COVID-19, the Air Force was developing immersive training devices that would help instruct students remotely as part of Air Education and Training Command's Pilot Training Next program, says Lt. Col. Ryan Riley, commander of Detachment 24. Instead of the pupil coming into the office, receiving an in-person brief, locating a training device and executing a mission, Riley's team was looking at how to conduct those events with both the student and instructor at separate locations.

"What we wanted to see, prior to COVID-19, was how far [we could] push the bounds of remote instruction," Riley says.

The pandemic turned that desire into a need to provide students the same level of instruction remotely as they would in person.

The Air Force and training companies were already working to develop virtual training systems when COVID-19 struck, and the pandemic seems to have accelerated adoption. "There are only so many places to train," says Todd Probert, defense and security group president at CAE. Though the military was once reluctant to fully tap into distance training, the question has become: "Is there a way to centralize that instruction?" he says. Pilots more than 100 mi. from a training base would be required to quarantine for two weeks once they arrived.

The technology, however, was "very glitchy," Riley says. The main problem was latency. So the team got to work, disassembling hardware and issuing the newest equipment to students and some of the instructor corps. Another issue was the fact the detachment's home-use devices were running off a laptop. The team discovered that various software programs such as remote screen-sharing were taxing the central processing unit (CPU) heavily, overwhelming laptops, says Lt. Col. Robert Knapp, Detachment 24 operations officer.

"No matter how good a laptop you buy, they're just never going to run at the same speed as a desktop computer," Knapp says. "We took some of our older desktop computers that were in the building and sent those home with students to replace the laptops, which opened up a lot more CPU bandwidth."

The students also were asked to plug their devices into

their routers instead of using wireless home internet, which reduced latency and resulted in a more streamlined, less glitchy process.

Meanwhile, the Army was tackling similar challenges at Fort Rucker in Dale County, Alabama, where the service produces pilots to fly the Boeing AH-64 Apache and CH-47 Chinook and Sikorsky UH-60 Black Hawk. In addition to training its own pilots at Fort Rucker, the service also assists with the training of foreign military aviators from as many as 47 countries annually at the base.

The Army established a virtual instructor's course so that the instructor pilots could learn how to teach using a digital platform, says Maj. Gen. David Francis, U.S. Army Aviation Center of Excellence and Fort Rucker commanding general. "COVID-19 has enabled us to really take a look at ourselves and how we're delivering training," he says. Francis envisions a blend of in-person and virtual training once the crisis passes.

As the pandemic took hold, the Navy, too, set up remote instruction with unprecedented speed. With 45 students per class, the service would not have been able to comply with social distancing guidance from the Centers for Disease Con-



JENNIFER SPRADLIN/U.S. AIR FORCE

trol and Prevention, according to Lt. Tim Benoit, aviation preflight indoctrination instructor at Naval Aviation Schools Command located in Pensacola, Florida. So in just five days, the Navy created a digital classroom and launched classes for its student Coast Guard, Marine Corps and Navy pilots.

Benoit had selected flight instructors to test the new digital system, and the next day he prepared a presentation to train the rest of the instructors. "We were able to adapt to this without missing any productivity targets," Benoit says.

The Navy does not plan to employ remote instruction after the COVID-19 crisis but views the technology as an alternative when a natural disaster such as a hurricane hits. The service is recognizing the advantages of remote learning, however, which include saving time and money. Students have access to each session's recording and associated course materials, and the technology would allow students not in Pensacola to take the courses.

"It can also be used in conjunction with in-person training to prep students . . . and it's been used to enable guest speakers" in another city, Benoit says. "Those are some things that I think may persist beyond the pandemic." 📡

RECONNECTING PARTS

- > SUPPLIERS AWAIT MORE GUIDANCE BUT LIKELY ARE STILL TOO OPTIMISTIC
- > UP TO 20% OF LOWER TIERS COULD EXIT A&D IN CONSOLIDATION WAVE

Michael Bruno Washington

Developed countries may be opening their economies and loosening social-distancing restrictions, but for aerospace and defense suppliers, the debate is about how much worse things will get.

The dichotomy is spurred by falling demand for aviation-centered manufacturing that will only lessen further in coming years, while supply will see new challenges after COVID-19. But yet to come are decisions on how supply chains will be refashioned after cuts of 30-50%—or more—in monthly production rates of large commercial

Production has restarted across aerospace manufacturing after COVID-19 outbreaks, and inventory is another pressure point to manage.

aircraft, the core growth driver for the entire A&D industry.

Aircraft giants Airbus and Boeing and Tier 1 suppliers are contemplating such decisions now, several industry insiders tell Aviation Week. Actions could start emerging by the third or fourth quarter.

“There are a lot of big questions because first the OEMs need to decide what they want to do next with their coalitions of suppliers,” says Eric Bernardini, AlixPartners managing director and co-head of the consultan-

cy’s global A&D and aviation practice. “I don’t think they have officially answered that question.”

Suppliers are girding for more bad news. In June, Airbus is expected to update its midterm production plans for its narrowbodies and widebodies. While Boeing has not specifically scheduled an update of its own, analysts and advisors widely expect both leading aircraft OEMs to outline further cuts to monthly rates, as airline and lessor demand withered starting in March.

At the same time, smaller manufacturers are shelving new projects including the Mitsubishi SpaceJet regional aircraft (see page 21). Even the Lockheed Martin F-35, perhaps the single most protected aircraft pro-



AIRBUS

Production of large commercial aircraft is being slashed, especially of widebodies such as these Boeing 787s.

gram currently, will see 18-24 fewer deliveries this year due to the novel coronavirus crisis.

By late May, suppliers still had more questions than answers, according to what executives told Wall Street analysts in first-quarter teleconferences. For many, April program cutbacks announced by Airbus and Boeing had yet to be translated into purchase orders and other guidance for suppliers.

"Everybody is trying to show a good face because, first of all, the first quarter only had barely two weeks or three weeks [from] impact the crisis," says Bernardini. That almost certainly will change by July, when second-quarter financial results start being revealed, either fully or in advance warnings to investors. "I suspect that when the second-quarter numbers come up in the next earnings calls, there will be a different conversation when they show and share the damage—first in their top line, and second, of course, on their supplier base."

As many as a fifth of lower-tier A&D suppliers could exit the sector over the next 18 months, seasoned supply chain experts tell Aviation Week. Some will go out of business, choose to merge into others or just walk away from A&D for other industries.

"Either through consolidation or attrition you're probably going to see a number closer to 20%," says Chris Celtruda, a former executive at the newly merged Aero Precision and Kellstrom Defense and a longtime partner to private equity investors. "The stress levels [and] liquidity challenges grow the deeper you go in the supply base."

He cites the 2013 federal sequestration as an example, when there was a similar, sudden softening of long-term business plans and 10-15% of smaller suppliers exited the business in the aftermath. But this downturn is worse. "I don't think we'll see a snap back. I think we'll see something similar to after 9/11," after which it took five years for airlines to get back to precrisis capacity levels.

Tier 1s and OEMs will provide financial lifelines to certain Tier 2-4 providers, especially those with intellectual property and that are critical parts providers. But many insiders expect bankruptcies and asset sales such as



inventory or manufacturing capability, while others may elect to go into other markets completely. One larger consultancy to large A&D clients says there is 30-50% extra capacity in the industrial base for the longer term.

That sober outlook is shared by Kevin Michaels, managing director of AeroDynamic Advisory and an Aviation Week guest columnist. "We're especially concerned about the Tier 2, 3 and 4 suppliers," he says. "Suppliers have really faced this whole litany of events that have happened. We had the supply chain squeeze from the [Boeing] Partnering for Success 1.0 and 2.0 and SCOPE+ at Airbus. Then suppliers were asked to deploy capex for a massive ramp-up in single-aisles. Then we had the [Boeing 737] MAX shutdown, and now we have the COVID-19 crisis. All of this has significantly weakened the supply chain."

Half of the defense supply chain is seeing cash concerns, Celtruda and Michaels say. There was "massive" idling of Northeast U.S. suppliers, home to engine-making ecosystems, and also in Washington state, Wichita, Dallas-Fort Worth, Arizona and California hubs.

Celtruda and Michaels stress it is not only a commercial aerospace issue but also a growing challenge to the defense industrial base, as evidenced by recent Pentagon concerns and the Joint Strike Fighter production rollback. Jefferies analysts estimate the Defense Department has pushed \$3 billion worth of accelerated payments into the supply chain. Defense officials acknowledge they have learned much more in recent months how the defense industrial base is dependent on the commercial market.

That was not always the case. As Tom Mayor, a KPMG partner and industrial manufacturing strategy practice leader, puts it, around the start of the Vietnam War, the U.S. industry saw roughly equal work on the commercial and defense sides. But since then, it has changed to 70-80% in favor of commercial. With the latter suddenly flagging for the next 3-5 years due to the pandemic, the whole industrial foundation will be rocked.

Which sector is most at risk? Several commenters list aerostructures first, as the segment was fragmented and suffering lower pretax profit margins before the crisis. Maintenance, repair and overhaul and parts suppliers to large civil aircraft also are listed, especially for widebodies and older airliners likely to be favored for retirement. Several publicly traded suppliers are exposed to varying degrees (see tables, page 38).

Boeing and its suppliers are seen as more vulnerable than Airbus and its ecosystem, both because MAX production is practically null and because there are around 800 inventoried 737s to be delivered in addition to customers' own parked aircraft. Besides reduced passenger demand subduing aircraft needs, lessors eager to rent out their own increased inventory will compete with new deliveries and orders.

"The long backlog does provide some certainty, but we expect a significant amount of cancellations and deferrals to be the story of 2020," says the Jefferies analyst team led by Sheila Kahyaoglu.

Bernardini has a similar view. "Some of our customers in the airline industry, they don't want to spend \$1 on a new delivery," he says.

Supplier Exposure by Aircraft Platform

Percentage of 2020 Estimated Revenue

BOEING							
737		747		777		787	
Spirit AeroSystems	48.2%	Triumph Group	5.2%	Boeing	17.3%	Boeing	19.2%
Boeing	22.3	Spirit AeroSystems	1.8	Spirit AeroSystems	16.9	Spirit AeroSystems	16.1
Hexcel	10.5	Boeing	1.7	Hexcel	7.7	Hexcel	10.1
Triumph Group	8.4	Hexcel	0.3	United Technologies*	3.6	United Technologies*	5.3
Woodward	5.9	Woodward	0.3	Triumph Group	2.9	Triumph Group	3.0
TransDigm Group	3.3	United Technologies*	0.2	TransDigm Group	1.0	Woodward	2.0
United Technologies*	2.9	TransDigm Group	0.0	Woodward	0.7	Honeywell International	1.2
Honeywell International	1.6			Honeywell International	0.3	TransDigm Group	1.2

AIRBUS							
A320		A330		A350		A380	
Hexcel	8.2%	Rolls-Royce	3.0%	Hexcel	12.4%	Hexcel	3.6%
Triumph Group	7.6	Triumph Group	2.5	Spirit AeroSystems	3.8	TransDigm Group	1.1
Spirit AeroSystems	7.4	Hexcel	1.1	United Technologies*	2.7	United Technologies*	1.1
United Technologies*	4.8	Spirit AeroSystems	0.8	Honeywell International	1.6	Woodward	0.4
TransDigm Group	3.6	Woodward	0.5	TransDigm Group	1.4	Spirit AeroSystems	0.4
Woodward	3.4	United Technologies Aero*	0.4	Triumph Group	0.7	Honeywell International	0.2
Honeywell International	0.6	Honeywell International	0.1				
		TransDigm Group	0.1				

EMBRAER	
E2 Family	
Triumph Group	4.0%
Woodward	1.2
Rockwell Collins*	1.0
Moog	1.0
United Technologies*	0.8
Honeywell International	0.2

*Now Raytheon Technologies

Sources: Jefferies and companies

Kahyaoglu's team forecasts annual deliveries will be "relatively flat" from 2019 through 2023 as deliveries recover following an expected 30% decline this year. Narrowbody deliveries are expected to fall 16% this year, with the return to MAX deliveries offset by lower airline demand due to the decline in utilization because of COVID-19. Widebody production and deliveries are expected to fall 63% in 2020, driven by lower utilization for long-haul flights as international cancellations climb higher.

Retirements are expected to affect up to 3.3% of the fleet this year, the team

further says. "We estimate retirements will rise over the next four years to more than 7% in 2023," the Jefferies group said in a late-May report. "The older aircraft that are currently parked may be permanently retired as airlines look to balance supply with a new level of lower demand." What is more, the current level of the parked fleet is almost threefold what was reached after 9/11 and fourfold following the 2008 financial crisis.

That all means lower revenue and worsening financial metrics for suppliers, almost all of which built up staff and fixed assets to meet prepandemic historic levels of A&D business. But in talking with industry customers, consultant Bernardini says he still hears too much optimism and an aversion to worst-case planning. "The first thing you need to make sure is that you have the go-dark scenario," he says. "The second thing we do is see if they're short on liquidity." Next come how to resize your company and how to restructure your own supply chain.

According to many industry advisors, the downturn came so suddenly that OEMs and top-tier suppliers did not have time to properly plan new

supply bases. Decisions are going to be rushed, partly based on liquidity crunches at smaller suppliers. Production rates could hover above delivery rates for several quarters just to allow supply chains to adapt, but eventually they will be lowered further, likely eliminating more suppliers.

"You won't be able to support everybody," Bernardini says. OEMs and Tier 1s will make decisions based on supplier reliability and relationships, he predicts. If someone desirable is distressed or too small to survive at lower business levels, OEMs and Tier 1s will be tempted to transfer work—but possibly still demand the same pricing as before.

"Of course, the supplier is going to say, 'How can I give you the same pricing if I'm doing 25 shifts [when] you asked for 50?' The [customer] will say, 'Well, because I'm giving you more volume or business, so you can absorb all fixed costs.'"

Adds Bernardini: "You're going to have a lot of discussion like this, and it may or may not work, depending on the supplier and the segment of the supply chain we're talking about." 🗨️

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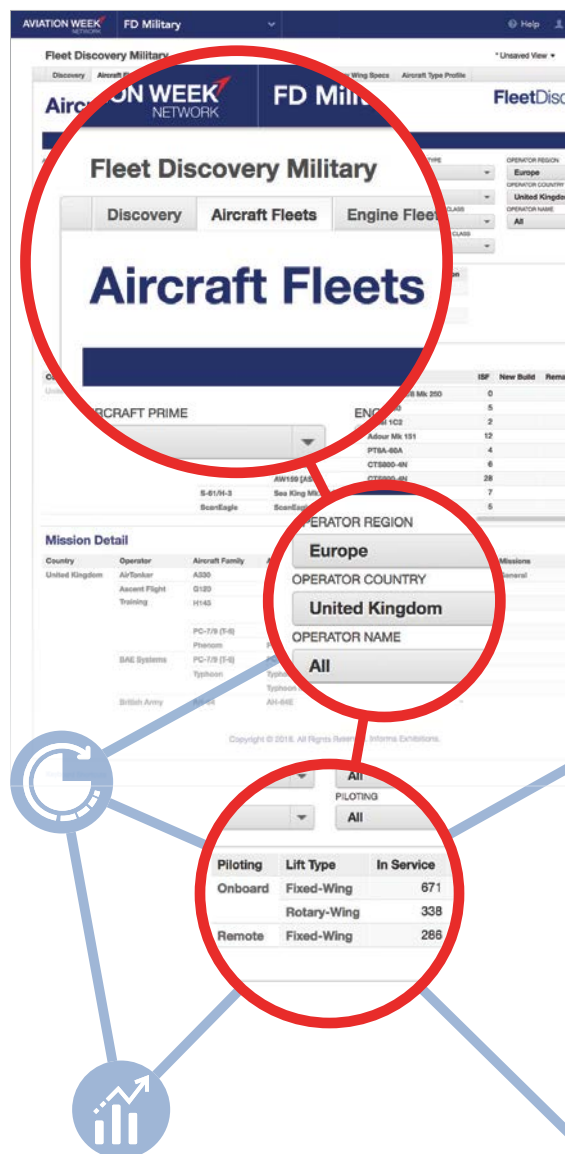
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ADDITIVELY SOBER

> 3D PRINTING MACHINES FALL SHORT, STANDARDS ARE UNRESOLVED, AND TRAINING IS MISSING

> THE TECHNOLOGY IN A&D STILL COULD SEE 17% COMPOUND ANNUAL GROWTH RATE



ASCENT AEROSPACE IT

Michael Bruno Washington

After decades of tinkering and years of major investments, aerospace and defense companies finally have found resonant missions for their 3D printers.

The catch: It is for personal protective equipment (PPE), the face masks and gear in strong demand following the COVID-19 outbreak, not for A&D products.

In April, Boeing announced it was activating its additive manufacturing (AM) network to create parts for face shields using 3D printing. The giant A&D company targeted an initial production rate of several thousand a week. Unionized workers donated overtime, and AM machines from St. Louis to Puget Sound in Washington to Huntington Beach, California, and Huntsville, Alabama, were engaged. Boeing's advanced technology subsidiaries Argon ST and Aurora Flight Sciences also participated.

Airbus and Raytheon Technologies, the other two leading A&D companies

by annual revenue, announced similar efforts, with the latter engaging nearly 70 3D printers across its global locations to produce as many as 2,500 face shield headbands a week.

To be sure, the surge of 3D-printed PPE from A&D represents the sector pivoting to address an immediate public crisis. Yet A&D's AM machinery has never been so universally marshaled, marking a climax for an advanced technology that has been decades in development but short of paradigm-shifting results inside industry. Why is that?

Like flying cars and orbital space tourism, 3D-printed aircraft have remained a distant goal passed from generation to generation. Now, as A&D enters a new phase of post-pandemic business conditions, AM evangelists are seeing both reason

Ascent Aerospace, a provider of aerospace tooling systems, factory automation and integration, in May unveiled its large-format additive manufacturing machine. It was installed in Santa Ana, California, alongside Ascent's composite tooling shop, autoclave and clean room.

for optimism and sobering reminders why manufacturing in the sector has not fundamentally changed.

"You've got to have some hype to get to the point where someone says, 'Yes, I'm going to buy \$5 million of laser wire deposition equipment,'" says Laura Ely, a former leader of GKN Aerospace's AM efforts who is now an industry advisor at the Barnes Group. "The problem that we have now is it's so overhyped that it's just, like, 'stop.' We don't need any more evangelizing. We need people [who] understand how to get out of the trough."

Ely and others point to the "Gartner hype curve" for AM in A&D, a chart

produced by the eponymous consultancy and popular at industry conferences for the way it visualizes the adoption of 3D printing (see chart). Gartner in 2019 placed A&D AM near the bottom of a downslope entering the “trough of disillusionment.” It will take 5-10 years before 3D printing in A&D gets to the “plateau of productivity.”

“There are examples where the industry is more advanced than that, where people would definitely argue, ‘No, we’re walking up the slope of enlightenment. We’ve got our production factory, and we’re getting closer to that plateau of productivity,’” says Ely. “But that is more the exception than the norm. The examples are there, but it is definitely not something that would be true across the industry. That might represent the 5% that are playing in additive manufacturing.”

According to several interviews and reports, what is holding back A&D is its cultural rigidity—often a benefit in maintaining high safety levels but also a hindrance to innovation—as well as more corporate-level issues including insufficient personnel training and challenging business cases. There also are issues in matching 3D-printing realities to A&D needs.

It has been a long time in the making. The first technologies were in the 1980s, and the first metals and workflows came in the 1990s. But investment casting and sintering of green parts came only in 2006-10, when in-

dustry genuinely saw the first class of structural-grade output directly from 3D printers.

“Aerospace companies grasped the technology in the 1990s,” says Scott Killian, business development manager for aerospace at EOS, a provider of metal and polymer laser-sintering AM machines, materials and services. Killian has more than 25 years in the sector, dating to DTM, a forerunner provider. He recalls the excitement in industry after GE Aviation unveiled the 3D-printed Leap engine fuel nozzle in the early 2010s. “We really expected a lot of other people to kind of pile on with that,” he says. “And then, for lack of a better term, things seemed to stall a little bit.”

Juan Carlos Munguia Castaneda is engineering director at M Aerospace RTC and recently presented at the SAE AeroTech Digital Summit. He has a master’s degree in aerospace design with a focus on additive manufacturing and has worked for suppliers such as Collins Aerospace, now part of Raytheon Technologies. He and Ely note that there are still many limitations on the supply side of 3D printing.

“Equipment manufacturers are not quite hitting the bar of people’s expectations,” Ely says. “If you buy a standard CNC [machine], you have a set of expectations from really any supplier . . . that things will operate correctly, so we won’t have to do mas-

sive amounts of tweaking on it.

“With any of the major [A&D] manufacturers, you hear a story of a lemon that they got from them—every single one,” she continues. That becomes an issue because industry is looking for applications, not experiments. “I do feel that the general consumer, they’re past the point of ‘I’m just going to buy a machine just to play around with,’” Ely adds.

There also are gaps in what is needed. “Unfortunately, even though there are a lot of companies trying to speed up and produce new powders, filaments and materials for additive manufacturing, we still have some limitations about which materials we have on the market,” Castaneda says.

At the same time, both Castaneda and Ely point to shortfalls in A&D practitioners applying AM. “If you don’t do an optimization of the part, you will have weight concerns,” Castaneda says. “It will use a lot of material instead of reducing the material you are using.”

Another compounding challenge is surface finishes. There are many efforts to improve the printing itself, but most of the time further finishing is required once it is out of the printer to get to final specs. This begets inconsistencies, the demon of quality control in replication.

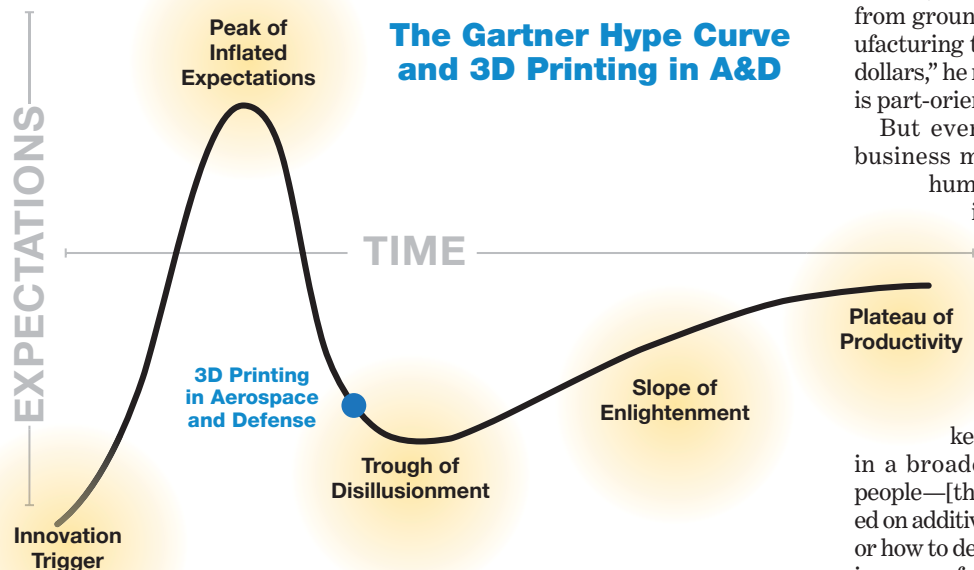
“There are not a lot of industry standards yet for additive processes, and the aerospace business is all about standards,” Killian says. Related to that, “to get a part on an airplane from ground zero with additive manufacturing to actually fly is millions of dollars,” he notes, because certification is part-oriented.

But even as the machinery and business model remain challenges, human resources are a bigger issue. “There is a lot of lack of training—not a lot of people actually know how to use additive manufacturing,” Castaneda says.

Ely agrees. “What is the biggest thing that’s keeping AM from being used in a broader sense? The answer is people—[they] are not broadly educated on additive manufacturing processes or how to design with them or use them in a manufacturing setting,” she says.

“Aerospace is what we call a risk-averse industry,” notes Patrick

The Gartner Hype Curve and 3D Printing in A&D



Source: Gartner

Dunne, vice president for advanced application development at 3D Systems and a longtime proponent for AM in A&D.

“What I do see generally is it is the fresh-out-of-college, inexperienced [folks who] have never been shouted at by design for manufacturing folks actually lead to iterations. . . . Folks who know what they’re doing would never have considered it in the first place,” he says. “Now we have folks that have grown up in a world where 3D printing has always existed. It’s not a novelty item anymore to them, it’s another tool in the toolbox.”

In her current advisory job, Ely says she encounters the same problem across industry. Clients say, “We bought a machine, it costs a lot of money; we’re kind of struggling a little bit, and we don’t really know what to do next.’ That is a really common one.”

The solutions, according to Ely, often are elementary: Have you plotted your qualification and certification plan? Have you gotten the machine calmed down and qualified?

Despite the frustrations, there is widespread agreement that AM’s role will continue to grow in A&D. The aerospace 3D-printing market was estimated at \$1.86 billion in 2019 and is expected to grow at a compound annual growth rate (CAGR) of almost 17% over the next seven years to \$6.72 billion in 2027. In January, market research companies Million Insights and Stratview Research separately said A&D will be a key customer propelling the greater 3D-printing industry this decade, with a CAGR of 34%.

Killian says the next five years will bring a dramatic pickup in utilization. Interestingly, the coronavirus pandemic is not expected to have much of an effect on AM utilization. Part of that is because it still is not applicable to around 75% of A&D manufacturing, especially larger aircraft subsystems and flight-critical parts—and may not be for a long time to come.

“There are millions of parts out there [on which] you shouldn’t even be wasting time trying to put it in additive; you cannot get any benefit

from it,” Killian says.

“Direct metal printing will really only be applicable for small, thin-wall, highly detailed components,” Dunnes notes. “That’s the reality, so [it would be] fuel injectors and small little brackets and stuff like that. It doesn’t make sense economically to use it for big parts. For indirect metals, which we class as investment casting, there are far better economics with investment casting and far more opportunities.”

Meanwhile, Ely and Killian point to the space sector, as the advent of a commercial low-Earth-orbit marketplace allows more from-scratch design and manufacturing. “The people who are really advancing in particular with additive manufacturing are people in the space arena, and part of that has to do with how mission-critical hardware is certified,” Ely says.

“There are not lots of volumes right now, so that means there are not a whole lot of machines out there building tons of rocket parts yet,” says Killian. “But it’s going to happen, and we’re pretty excited about it.”



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> GENERATIVE DESIGN PRODUCES STRUCTURALLY OPTIMIZED PARTS

> OPTIMIZATION IS EXPANDING INTO OTHER DOMAINS

Graham Warwick Washington

For the providers of the software tools used in aerospace design offices around the world, the capability is already in place to enable engineers to create better parts using additive manufacturing. What is holding the technology back is its economics compared with the traditional manufacturing processes used across the industry.

Once the cost and time required to certify the powder materials have been reduced and the processes to finish the parts after printing have been automated, then the powerful optimization tools that have been placed at the fingertips of design engineers can be fully exploited, software providers say.

"We are on journeys with a number of customers to do what we call industrialized additive manufacturing," says Aaron Frankel, additive manufacturing software program vice president at Siemens Digital Industries Software. "We are looking to enable companies to design-optimized applications and then produce those parts in large volumes."

"The design technology has been deployed for a couple of years now," says David Zeigler, aerospace and defense industry vice president at Dassault Systemes. "If you look at the different segments, additive manufacturing is really getting more traction in the space domain, where they are looking at doing 70% of their components in additive manufacturing."

The technology is more developed in space than in commercial aviation because the applications are targeting the weight saving, which is up to 40% over traditional manufacturing methods such as casting or forging. "When

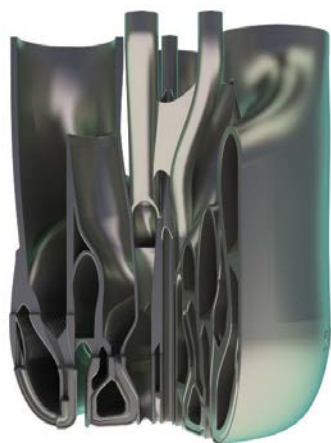
we're talking about spaceflight, 1 lb. costs \$10,000 to launch," says Frankel. "Companies tell me they are willing to pay \$2,000-3,000 more for a part that delivers a 1-lb. weight saving."

Additive manufacturing (AM) can also reduce assembly steps by a factor of 10, by consolidating parts and reducing the buy-to-fly ratio of raw material to finished part by a factor of 10.

"The question today is not whether additive manufacturing is a great technology, but when it can move into the realm of industrialization," says Zeigler. "The reason it is more successful in space than in commercial aviation is because of competition with traditional manufacturing methods, which for long-series production are still more economical."

Zeigler does not believe engineer training or skills are holding AM back, because the design software available today provides the capabilities needed to exploit the technology. "We are providing generative design tools that allow you to start the design of your part in a CAD [computer-aided design] environment, optimize the topology of the structure, run all the simulations in terms of stress and prepare all the manufacturing engineering," he says. "It is a one-stop shop to give all the engineers in the design office the capability to do all the processes."

This represents a fundamental shift in the role of the design engineer. Traditionally, the process would start with a CAD part, its topology would be optimized in a different tool, and finite-element analysis to determine the residual stresses in the part would



Generative engineering uses simulation to create optimized designs within constraints set by the engineer.

use another tool in a different workplace. "If that part did not work, you would go back to Step 1, and the loop would take a couple of weeks to converge," says Zeigler. "What we have achieved is to reduce that couple of weeks to a couple of hours—and under the same roof."

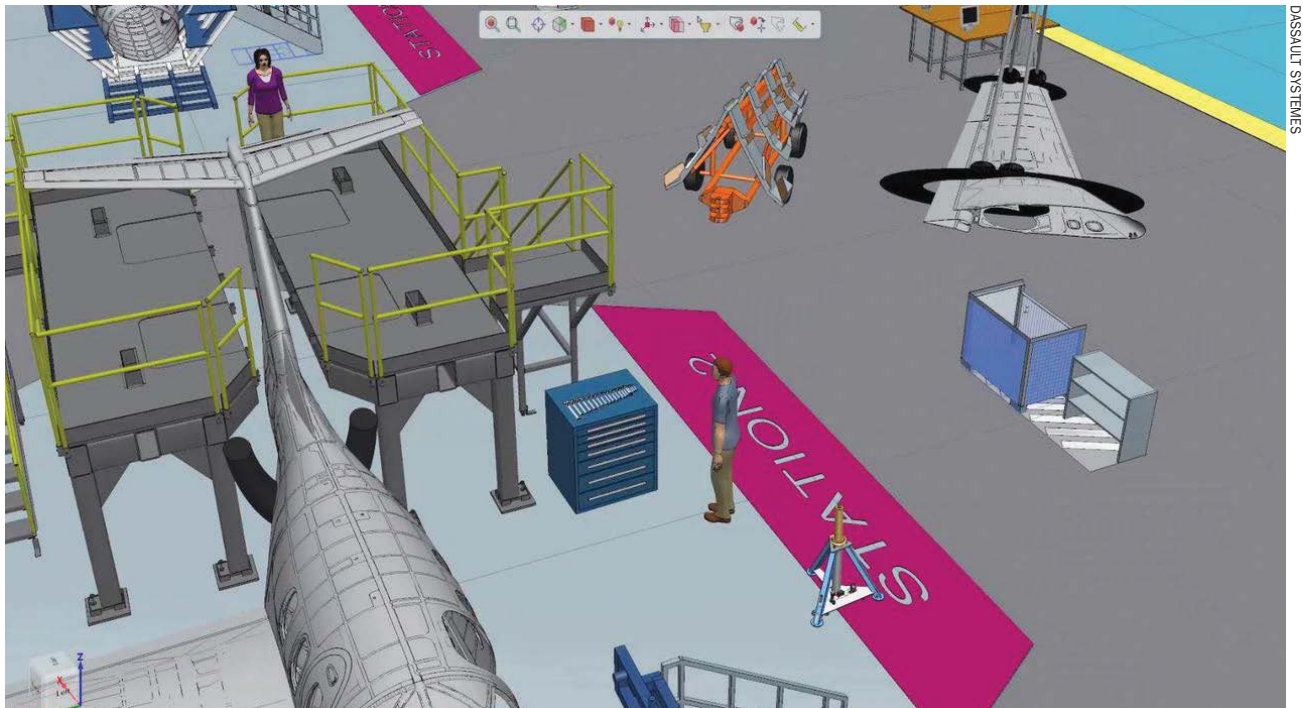
Generative engineering and topology optimization are putting simulation-based tools at the engineer's fingertips, giving them an automated capability to explore a wider design space and create a better part. "The companies that are embracing generative engineering and 3D printing are on a path to disrupt their industry," says Frankel. But it is no easy task. "First they need to find the ideal material for the application. Then they need to create the ideal design. Then they have to qualify the process to produce it repeatably and flawlessly. Then, finally, the parts they make have to be certified. It's a big challenge."

Additive manufacturing and generative design "are inverting the natural order of engineering," says Frankel. "Designers used to worry about creating the form of a product, and the engineers' responsibility was to test whether it accomplished its function. Now the designer is specifying the function and the engineering software is automatically determining the form."

More so than AM, perhaps, it is the optimization tools that will bring the biggest change to aerospace, because they work with all manufacturing processes. "Looking ahead, we will have generative engineering for more than the design of products. We'll be looking at leveraging generative engineering for manufacturing, using simulation-based applications to determine the optimal routing for a product through the factory based on the equipment available," Frankel says.

Simulation-based optimization has been around for 30 years but began in the domain of computer-aided engineering (CAE), which comes after CAD and replaces physical testing for design validation. "It didn't guide the designer a lot, but it facilitated the validation process," says Dhiren Marjadi, global aerospace business vice president at optimization pioneer Altair.

The recent shift has been to move optimization to the front of the design cycle. "Automotive companies are using it before CAD nowadays," he says. "It comes before CAD and we are doing



things like motion, structural and CFD [computational fluid dynamics] analysis and optimization and manufacturability simulation so that the designer creates a part that meets the structural and other requirements but also meets the manufacturability requirements. We believe that CAD is now essentially documenting the design.”

Typically, simulation has been used for virtual testing. “Generative design and topology optimization flip that on its head,” says Jeff Blanford, pre-sales solution consultant at Siemens. “Simulation is being used to generate the design from the beginning rather than being an afterward check. That’s where the value lies, because now you are blurring the line between simulation, design and manufacturing.”

Initially used at the part level to remove weight by optimizing the geometry, topology optimization is now being expanded to assemblies and into domains beyond structural design. Used in the automotive sector, Altair’s C123 process begins with load-path identification to optimize the overall vehicle configuration, then rapid sizing of structural load paths and finally detail design and creation of the bills of materials and processes.

Altair has also demonstrated global-level topology optimization under a U.S. Navy project. It took the mission requirements for a vertical-take-off-and-landing unmanned aircraft, performed a high-level system opti-

mization to produce a vehicle concept, then transitioned that 1D mathematical simulation into 3D for CFD analysis and structural optimization. “Normally, everything you do in the 1D world gets lost when you go to 3D,” Marjadi says.

Topology optimization is being expanded from individual components to assembly-level design and from single to multiple configuration options in search of the best design. “Topology optimization almost becomes a loop within the loop,” says Blanford. “I will have a tool that will alter the parameters for each iteration and for every iteration run a topology optimization based on that new constraint set. That’s where our customers are trying to attack that holy grail of generative design.”

Optimization is also expanding into other domains, including flow and thermal, not just to reduce part weight but to improve system performance. Optimizing the flow in ducts, for example, would reduce the size of motors required to move air and fluid around aircraft, which would save weight, says Frankel.

Here additive manufacturing comes back into the picture, because generative engineering can result in designs that can only be produced using AM. The key is automating the process to turn topology-optimized designs into practical parts that can go directly into virtual validation and on to 3D printing. Machine learning is also

Topology optimization is being expanded to enable the simulation of the entire factory.

coming into the picture, for example to model and predict the fatigue life of AM parts based on local material properties, loads, build orientation, surface finish and post-processing.

Generative engineering can even help the designer perform a trade-off analysis between manufacturing processes. “If the focus is weight, most probably additive will be the winner,” says Zeigler. “What our customers are doing now is building their cost indexes into [generative design] to perform trade-off analyses of the cost of producing a part versus the manufacturing technology.”

There is a cultural challenge when it comes to the blurring of lines between design, simulation and manufacturing. “Those users who take advantage of generative design and additive manufacturing are typically those who are willing to go outside their comfort zone. They have the most value to the company,” says Blanford.

“We’ve reached an inflection point in engineering, where we’ve moved from an emphasis on people doing the engineering to an emphasis on the software,” says Frankel. “Engineers are not going away. We are going to need engineers, but they are going to know more than our typical siloed engineers did in the past.”

Europe's GPS Augmentation System Aims at Category 2 Approaches

> FUTURE EGNOS WILL ENABLE CATEGORY 1 WORLDWIDE

> GPS' AND GALILEO'S FUTURE CAPABILITIES WILL BE LEVERAGED

Thierry Dubois Lyon

The contracts that the European Space Agency recently awarded for upgrades to the European Geostationary Navigation Overlay Service (EGNOS, a GPS augmentation system) are another sign of the EU's consistent move toward satellite-based navigation for commercial aviation.

Satellite navigation is independent from navigation aids on the ground; therefore, the overall cost for the industry is deemed lower. Benefits are expected especially for airport approaches, but the service can be provided anywhere—making it easy to adapt to evolving traffic.

The first upgrade under consideration centers on improving the approach performance to Category 2 (Cat. 2). This involves a decision height (DH, the lowest elevation for the crew to decide whether to proceed with landing or perform a go-around) of 100 ft. EGNOS' current performance stands at Cat. 1, with a DH of 200 ft.

Receiving two signals instead of one is a crucial change at the aircraft level. The current EGNOS system is using only the GPS L1 signal. The upgrade to be introduced will make the most of the addition of the L5 signal into the GPS architecture. Moreover, the updated EGNOS system will use both GPS and Galileo, the latter also transmitting in L1 and L5.

"Thanks to this increased augmentation, a new EGNOS receiver will benefit from increased availability and continuity of service for vertical guidance," European Space Agency (ESA) Navigation Director Paul Verhoef says. The vertical alert limit (the maximum allowable vertical position error) is reduced to 33 ft., down from 115 ft., thus allowing a lower DH, he says.

"The dual-frequency capability is key [because] it removes the uncertainty on ionospheric interference," says Philippe Merlo, Eurocontrol's director of European civil and military aviation. Eurocontrol is the organization in charge of air traffic

management in Europe. A source of inaccuracy, ionospheric interference can be evaluated, thanks to dual-frequency technology, he explains. Dual-frequency design also makes the system more robust against malicious interference.

The upgrade is in a proof-of-concept phase. "It will be ready for demonstration within 15 months," says Michel

Monnerat, navigation domain bid and advanced projects director at Thales Alenia Space. The two contracts for study and development, awarded in May, are part of the EU's Horizon 2020 research and technology program. ESA is acting on behalf of the EU. The European GNSS Agency, known as GSA, operates EGNOS and Galileo.

Monnerat, navigation domain bid and advanced projects director at Thales Alenia Space. The two contracts for study and development, awarded in May, are part of the EU's Horizon 2020 research and technology program. ESA is acting on behalf of the EU. The European GNSS Agency, known as GSA, operates EGNOS and Galileo.

Monnerat notes. "In 2028, Cat. 1 approaches will be required to use EGNOS only," Monnerat notes.

More pressing is the recent European regulation that calls for every airport equipped with a ground-based instrument landing system (ILS) to create a similar EGNOS approach by 2024. In case of ILS failure or maintenance, EGNOS would ensure the availability of a Cat. 1 approach.

As satellite navigation availability and adoption ramps up, the decom-

An increasing number of aircraft types such as the Airbus A350 (pictured) include EGNOS receivers for satellite-based navigation.



mission of navigation aids on the ground will accelerate.

The other upgrade for which Thales Alenia Space has received a study contract is about verifying navigation satellite signal integrity—internal consistency and absence of corruption—worldwide.

On the next generation of Galileo satellites, the signal will include integrity information. It will support the advanced receiver autonomous integrity monitoring (A-RAIM) concept, whereby integrity is mainly assessed onboard. A-RAIM uses GPS and Galileo as well as information computed by a dedicated ground segment. Therefore, with A-RAIM, Galileo and EGNOS will open the possibility to create Cat. 1 approaches with vertical guidance worldwide, Monnerat says. 🌐

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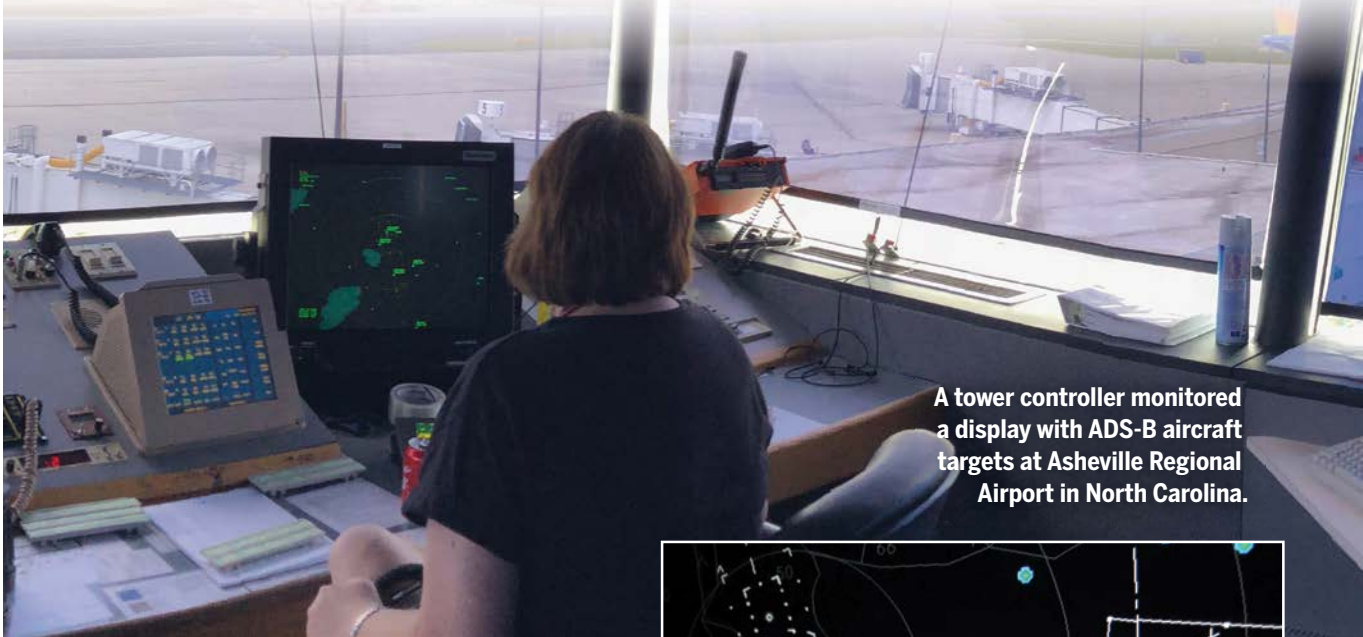
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'Preferred' Surveillance

> PANDEMIC DELAYS ANALYSIS
OF ADS-B BENEFITS

> CLOSER SEPARATIONS USED
IN SEATTLE AND BOSTON



A tower controller monitored a display with ADS-B aircraft targets at Asheville Regional Airport in North Carolina.

Bill Carey Washington

January marked a milestone in the FAA's implementation of automatic dependent surveillance-broadcast, a core program of the agency's long-running NextGen modernization that complements radar with a satellite-based method of tracking aircraft, providing greater overall coverage, better accuracy and higher update rates.

As of Jan. 1, the FAA required that aircraft flying in most U.S.-controlled airspace be equipped with transponders that continuously broadcast their GPS-derived position and identity to ground controllers, the function called automatic dependent surveillance-broadcast (ADS-B) Out.

The ADS-B ground infrastructure of 658 nationwide radio sites, owned and operated by L3Harris Technologies for the FAA, was completed in 2014. The FAA has integrated the system at 24 en route air traffic control (ATC) facilities and 155 terminal radar approach control (Tracon) facilities.

In October 2019, the FAA said it had started using the surveillance system at the last two of 155 airports to receive ADS-B: Akron-Canton Airport and Mansfield Lahm Regional Airport, both in Ohio.

Then this year, the COVID-19 pandemic struck. President Donald Trump declared a national emergency on March 13, and four days later the FAA announced the first temporary closure of an ATC facility—the tower at Chicago Midway International Airport—after multiple technicians there tested positive for the coronavirus.

The agency listed 50 ATC facilities that have been affected by the virus as of June 1.

The suppression of air travel caused by the pandemic must be considered in gauging the readiness of tens of thousands of aircraft operators for the ADS-B equipage mandate. But the FAA says it is pleased with the levels of compliance thus



FAA PHOTOS

Controller displays fuse data from different surveillance sensors. Aircraft that are not transmitting by ADS-B are tagged with a white circle preceding the call sign. In this photo, N1634F is equipped with ADS-B, while N1173X is not.

far, as indicated by the number of "ADS-B aircraft detected."

That figure, tracked by an ADS-B Performance Monitor at the FAA Technical Center near Atlantic City, New Jersey, represents the number of aircraft transmitting unique 24-bit International Civil Aviation Organization addresses to ground stations during the past two years.

As of June 1, the FAA had detected 126,825 aircraft that comply with ADS-B Out requirements. Of these, 105,247 were general aviation (GA) fixed-wing, experimental and light-sport aircraft and helicopters; 6,553 were airliners.

The balance of 15,025 aircraft were counted as ADS-B-equipped but not revealed to the public by category, including U.S. military and government special-use aircraft, gliders and drones.

Under the equipment mandate, aircraft flying above

18,000 ft. must be equipped with 1090ES Mode S extended squitter transponders to broadcast their position; lower-flying aircraft can use either 1090ES or Universal Access Transceivers (UAT) operating at 978 MHz.

Of the total ADS-B-compliant aircraft detected, the FAA says, 99,047 were equipped with 1090ES Mode S transponders, 26,590 with UAT, and 1,188 with both 1090ES and UAT avionics.

The FAA says approximately 100% of airliners are now ADS-B-equipped. The number of GA aircraft detected (105,247) represents about 69% of the 153,000 GA airplanes, business jets, helicopters, experimental aircraft and light-sport aircraft that flew through ADS-B surveillance airspace before the mandate entered force—an estimate obtained from the Aircraft Owners and Pilots Association.

The sharp decline in air traffic movements because of the coronavirus pandemic skews any evaluation of the promised safety and efficiency benefits of ADS-B, such as the capability the system provides to reduce aircraft separations in congested airspace. Nevertheless, the FAA has forged ahead with what it calls its “preferred” method of surveillance.

Data from aircraft broadcasting by ADS-B is fused on controller displays with available information from primary radars, secondary surveillance radars (SSR) and multilateration stations.

“The public health emergency definitely is changing our environment every day,” says Ammyanna Williams, FAA surveillance and broadcast services group manager. “The environment is so fluid, we are not drawing any conclusions and are evaluating [the system] over time, but ADS-B is providing support as usual. Our performance has not changed because of the health emergency.”

The implementation of the ADS-B surveillance layer has provided the FAA with one benefit it can quantify: the opportunity to assess its existing radar “footprint” and remove radars in overlapping areas where they are no longer needed. Between fiscal 2020-25, the agency plans to divest 14% of terminal-area radars in the national airspace system (NAS), which it estimates will save \$400 million in operating, maintenance and sustainment costs through 2035.

Most radar sites are collocated primary and SSR facilities, and one or both radar types could be retired depending on a safety analysis. Safety and the ability to provide continuity of air traffic services in the areas served by radars will be “heavily looked at” in decisions to divest radars, an FAA program executive says.

In addition to the ADS-B equipage requirement that entered force in January, this year was also a pivotal year for the FAA’s plan to close aircraft separations to 3 nm from 5 nm in en route airspace, taking advantage of the system’s once-per-second update rate.

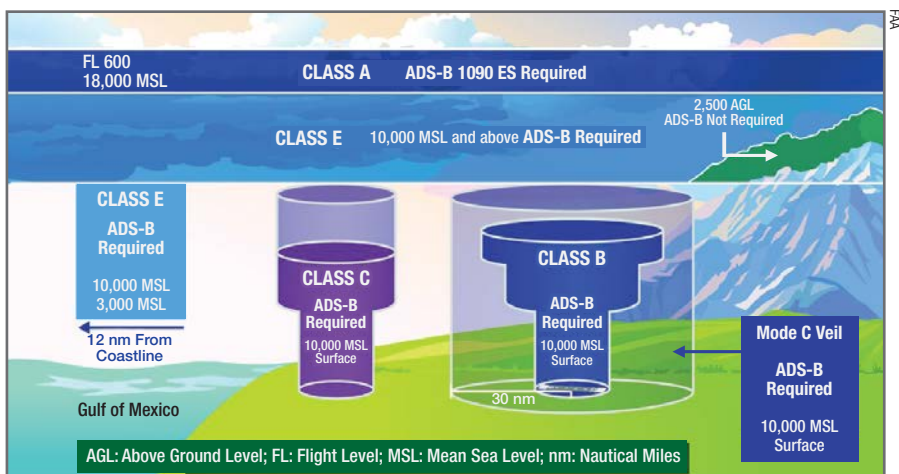
The FAA has started applying 3-nm separations in the Boston and Seattle areas, the first key sites of a planned nationwide expansion of the tighter separation standard over the next two years. Controllers apply the separations at Flight Level 230 (23,000 ft.), the point at which air route traffic control centers (ARTCC) hand off aircraft to Tracons.

“This is huge because ADS-B is filling in the gaps, and that’s resulting in a decrease in our predicted traffic conflicts as well as an increase in our NAS efficiency for operators who are using this airspace,” Williams says.

She adds: “ADS-B has created a seamless surveillance picture within our terminal environment, improving aircraft tracking throughout all of our Tracons, which enhances also our operational safety and efficiency. The terminal airspace can get congested quickly. Any relief we can provide to help air traffic controllers and operators with common situational awareness is huge.”

The FAA announced in October 2018 that it would conduct an operational evaluation of the Aireon satellite-based ADS-B system in the Caribbean region from Florida to Puerto Rico, tracking aircraft over water from its Miami ARTCC. The one-year evaluation started as planned this March despite the pandemic, Williams says.

Aireon’s system captures ADS-B signals from aircraft using receivers carried as hosted payloads on Iridium NEXT low-Earth-orbit satellites, providing a surveillance



Aircraft must transmit by ADS-B Out in these airspace classes, including in Class B and Class C airspace surrounding large and smaller airports.

capability over oceanic tracts and remote areas outside the range of terrestrial ADS-B and radar systems. Until the Aireon system entered service in March 2019, controllers applied procedural separations based on intermittent, satellite-routed position reports to keep aircraft safely apart in such regions.

The FAA is evaluating “space-based” ADS-B as a gap-filling capability in oceanic airspace and potentially in remote areas where the installation of ground infrastructure is cost-prohibitive. This could eventually lead to reduced aircraft separations in FAA-controlled oceanic airspace.

“If the technology proves to be viable, space-based ADS-B can fill that gap [in oceanic airspace],” Williams says. Based on the findings of the Caribbean evaluation, “we will make the appropriate recommendations on whether or not to sustain an operational capability in the existing airspace following conclusion of the one-year evaluation,” she says.

The FAA plans to conduct additional evaluations of space-based ADS-B in oceanic airspace around Bermuda, some small Pacific Ocean islands and Shemya, in the Alaskan Aleutian Islands chain, Williams says. ☼

FACE TO POINT TO



OPTIMISTIC

- > Increased demand for private aviation boosts aircraft use and sales
- > Demand for commercial pilots returns as airlines recover
- > Helicopter market recovers as oil prices increase

Graham Warwick Washington

Business and general aviation have seen downturns more than once before. As private flying shows the first signs of recovery from the blow struck by COVID-19, many in the industry think this time around could be different.

The forces acting on the market through the novel coronavirus pandemic are complex, but there are reasons to hope that, for some sectors at least, the

MANUFACTURERS

Business aviation was an industry in transition as it entered 2020. The sector never fully recovered from its downturn after the 2009 financial crisis. Manufacturers rationalized production and refreshed product lines in response. But for a market that grew giddily in the first years of the new century, only to crash, flat had become the new normal.

COVID-19 has triggered another downturn, but the industry believes the market will recover and may actually benefit in the aftermath of the pandemic. The factors behind the collapse of 2009—irrational exuberance, overproduction, wealth destruction and stigmatization—are not present this time, say market watchers.

Despite that downturn, the industry did not consolidate as many hoped it would. Entering 2020, nine manufacturers were chasing a market for 700-800 aircraft a year with 43 different models. Bombardier was exiting commercial aircraft and selling its rail business to focus on business aviation.

Embraer, meanwhile, was carving out its commercial aircraft business in anticipation of a joint venture with Boeing. But Boeing pulled out of the \$4.2 billion deal in April, forcing the Brazilian manufacturer to reintegrate the businesses, focus on conserving cash and put product

Charter operators are emphasizing health checks and cleaning programs to keep crews and staff safe while helping passengers feel comfortable.

development on hold until aviation recovers.

Bombardier says its aerospace divestitures remain on track to close this year, shoring up a balance sheet hit by a \$600-800 million first-quarter cash drain due to COVID-19. But the sell-off will leave it as the only business jet maker with no countervailing defense business. "That, I think, puts them in a vulnerable place," says Richard Aboulafia, vice president of analysis at the Teal Group.

The immediate effect of the pandemic was an inability to hand aircraft over to customers because of travel restrictions. Gulfstream was unable to deliver 13 aircraft in the first quarter but pulled forward two from the second quarter to end the period 11 aircraft down at 23, Phebe Novakovic, CEO of parent General Dynamics, told analysts on April 29.

Travel restrictions kept sales teams locked down, so manufacturers also reported a drop in orders for the first quarter. But cancellations were few. Novakovic said Gulfstream saw four customers cancel or default, three of which are

FACE: D POINT

NEUTRAL

- > Business aircraft deliveries return to pre-COVID-19 levels in 2021
- > International pilot training picks up as travel restrictions lift
- > Oil prices rally enough to sustain helicopter demand

PESSIMISTIC

- > Economic depression reduces business aircraft demand for 3+ years
- > Slow airline recovery keeps a large number of pilots furloughed
- > Persistently low oil prices collapse helicopter demand

recovery will be faster and stronger than for commercial aviation.

“Private aviation has always been the first into a recession and the last one out,” says Ian Moore, chief commercial officer of fleet operator VistaJet. “I think what’s happened means we could be the first one out, just due to the unique nature of the virus and the way people will travel in the future.”

expected to come back. Bombardier lost some deliveries but “we haven’t seen much cancellation,” new CEO Eric Martel told analysts on May 7.

Textron Aviation was hit by fractional operator and biggest customer NetJets’ decision to take only 25 aircraft this year, down from 60. “Their sales force saw the same thing we saw, which was people stopped as the pandemic hit,” Textron CEO Scott Donnelly told analysts on May 2. NetJets will continue to take Cessna Citation Latitudes and Longitudes for which it has customer commitments, he said.

Output was also hit by factory closures as COVID-19 spread. Textron announced furloughs starting March 23 and extended them through May 29. Bombardier plants in Canada, Northern Ireland and Mexico shut down in March and began to reopen in early May with new health and safety precautions in place—“a tremendous undertaking,” said Martel.

As production restarts, manufacturers are seeing weaknesses in the supply chain, particularly among suppliers also hurt by the disruption to commercial aircraft OEMs. “Hopefully, we can sort our way through these issues, but some of them are difficult,” Novakovic said. “We are working closely with them to provide on-site mitigation and support where we can and, ultimately, if we have to bring it in-house we will.”

Gulfstream’s reduced output this year will be driven “almost exclusively” by supply-chain issues, she said. “Some of our suppliers entered this crisis somewhat impaired both from exposure to the commercial aviation market and some financial difficulties.” They were having difficulty keeping up with the original production rate, and the crisis exacerbated this, she said.

“Many members have reported how government travel and other restrictions have impacted their operations, supply chain and deliveries, and how they are responding to these issues,” the General Aviation Manufacturers Association tells Aviation Week, noting the aviation supply chain encompasses tens of thousands of suppliers around the world.

Lost deliveries and sales, production interruptions and supplier issues are expected to cut business-jet deliveries by 30% or more in 2020, analysts at JPMorgan predict. “And while we assume a rebound in 2021, that leaves deliveries only about 15% below 2019,” the JPMorgan analysts add. “We do see downside risk.” That risk includes the impact on the market of the recession following the pandemic.

Anticipating lower demand because of a global economic slowdown, analysts at Jefferies forecast 40% fewer deliveries this year.

OPERATIONS

Business aviation activity has started to recover as travel restrictions are eased. After a flurry of activity in March flying owners and customers home to safety, flights in April fell by more than 70% from a year earlier. The biggest drops—more than 80%—were in fractional and large jet activity, reports Argus.

By mid-May, business aviation flights were down year-on-year by only 58%, a resilience that contrasts with the 85% drop in global scheduled airline activity, says WingX Advance. But the impact of the crisis has been severe. A survey by the European Business Aviation Association of member company CEOs revealed financial losses of 50-90% during the crisis, says Secretary General Athar Husain Khan.

Plummeting activity also hit fixed-base operators (FBO) and airports. Fuel sales collapsed. “The market just fell off a cliff. FBOs dropped to pumping 2% of what they were doing,” says Ryan Waguespack, senior vice president of the U.S. National Air Transportation Association (NATA). “In the last two weeks, we’ve seen more activity by the Part 135 operators and the FBOs.”

Activity is a key indicator of the health of business aviation, but only one of them. Gross domestic product and corporate profits are also strong signals of demand. The global economy is projected to contract by 3% in 2020, a far worse outcome than during the 2008-09 financial crisis, says the International Monetary Fund. “The global economy is projected to grow by 5.8% in 2021 as economic activity normalizes,” the IMF adds. “The risks for even more severe outcomes, however, are substantial.”

The correlation between corporate profits and aircraft demand is strong, but it has weakened since the 2009 recession for several reasons, say the JPMorgan analysts. Among the reasons is the stigma that became attached to business jets. “We expect corporate profits to remain one determinant of business-jet deliveries. As such, COVID-19 presents a great risk in the foreseeable future, with expected profit decline and reduced wealth, though it is unclear how tight the relationship will be going forward,” they say.

Another indicator of market health is used aircraft. A glut of young, pre-owned jets, almost 20% of the fleet, helped steepen the 2009 downturn by competing with new aircraft for sales. In May 2020, 1,823 pre-owned aircraft were available for sale, up 4% from a year earlier, according to Jeffries analysts. That represented 7.7% of the total worldwide aircraft fleet, well below the historical average of 12%. Average list prices were down 12% year-over-year.

The 2009 recession resulted in a bifurcation of the business-jet market: large-cabin demand continuing to grow while sales of small and medium aircraft fell. Coming out of COVID-19, there is concern it could be the lucrative large-aircraft market that suffers this time around. According to Jeffries analysts, the number of used heavy jets for sale was up 13% in May year-over-year, while light jet inventories were flat.

The reason for the trend is low oil prices. "There is a pretty clear correlation between energy prices and large-cabin business-jet demand, principally because an enormous part of this market is either energy extraction corporations or high-net-worth individuals and businesses dependent on resources for their economy," the Teal Group's Aboulafia told an April webinar by the International Aircraft Dealers Association (IADA). "We need a recovery in oil prices."

RECOVERY

One unknown factor in any recovery scenario is the extent, if any, to which post-pandemic health concerns will lead businesses to look at private aviation as a safer way to move executives and employees around—not only for health reasons but to provide more convenient point-to-point connections as the hard-hit commercial airlines slowly rebuild their networks.

"One of the outcomes that could occur as a result of this particular crisis is that businesses can ill afford to rely on those commercial airline providers who are either financially weak or unpredictable," said GD's Novakovic. "So the fundamental case for business aviation remains the same, if not somewhat strengthened by this crisis."

Any trend in this direction is expected to manifest first in demand for charter flights, then membership programs such as Wheels Up and on through jet cards and fractional shares offered by NetJets and others for used and new whole-aircraft ownership.

Citing discussions with NetJets and Wheels Up, Textron's Donnelly told analysts: "It's anecdotal at this point, but there's reason to have some optimism around the fact that we're seeing a lot of activity through those channels that are new folks potentially coming into the business-aviation industry."

Aircraft brokers and charter companies are seeing a jump in inquiries. "Charter operator sales departments are fielding call after call, the same way we're getting an increase in new buyers that have not owned an airplane but are interested in how much it costs to own and operate one," says Don Dwyer, co-managing partner at broker Guardian Jet.

"I've talked to different companies offering travel cards for charter and their activity is [through] the roof," Wayne Starling, IADA executive director, tells Aviation Week. "NetJets' card sales are up tremendously." NetJets and Wheels Up declined to comment.

"The number of flight inquiries that we've received is higher than last year," Adam Twidell, CEO of UK-based online charter broker PrivateFly, tells Aviation Week. "So we

know people are interested in using private aviation. And many of them are doing it for the very first time."

COVID-19 could also change how existing operators view their aircraft. Asked by a customer whether other companies with large flight departments were considering relaxing policies on personal use to protect executives, Guardian Jet asked around. "No one's really talking about that, not yet. But the overriding theme was discussions with their company about use of the corporate aircraft going deeper into the corporation," Dwyer tells Aviation Week.

Interest in charter and other channels is running concurrently, he says. "The common denominator is: 'I have to trav-



DASSAULT AVIATION

el, and I'd like to have more control over it.' I think charter and fractional could be the big winners, but right now it is interesting that almost every corporation we talked to said they were considering using their airplanes more, not less." Big flight departments have been reducing in size for the past five years. "This could slow that down," he says.

With charters likely to become the first beneficiary, there comes a challenge. Illegal charters were already a safety issue before the pandemic. With a surplus of furloughed pilots and distressed aircraft owners post-COVID-19, there is an increased risk of questionable flights offered at a fraction of the cost of legal charters, NATA's Waguespack says. "The FAA has done a good job in tightening up. Some risk might be there, but they have the skills to deal with it," says IADA's Starling.

The market is already responding with ways to make private aviation more accessible. MemberJets has launched a software platform making it easier for Part 135 operators to offer public charters on a per-seat basis. The program provides "instant access" to MemberJets' existing Part 380 approval, allowing the operator to "take a flight, advertise it as a scheduled flight and sell by the seat," says CEO Ty Carter.

With about 170 aircraft already in its prospectus, MemberJets provides the booking engine, surety bond and escrow account that allow operators to create public charters "on the go" for shuttle services or special-event flights. The program also allows jet-card holders to share flights with other members. "COVID-19 offers an opportunity to step up and fill a new void," Carter tells Aviation Week.

Funding from the Coronavirus Aid, Relief, and Economic Security Act has helped private aviation weather the pandemic. Few casualties are expected, Waguespack says, although U.S. operator JetSuite filed for bankruptcy protection in April citing slumping charter demand. Consolidation of the fragmented charter market is expected.

"This is a moment when the private jet user will want to rely on someone who's been there for a while," Twidell says. "For a smaller player in the industry, it's going to be increasingly hard." Twidell describes this as an "excellent time" to be acquired, as PrivateFly was by private-jet travel leader Directional Aviation.



Business aviation activity in Europe began to recover in May, but a significant fraction of the flights were COVID-19-related medical missions.

As they emerge from lockdown, operators have introduced health checks and cleaning programs throughout the flight process. NATA is also promulgating standards to ensure pilots and ground staff are safe and that passengers feel comfortable flying. "We have an opportunity to capture more market," Waguespack says.

FLIGHT TRAINING

Entering 2020, the flight-training industry was in growth mode, with demand for commercial crews fueled by airline growth, pilot retirements and higher flight experience requirements. That growth had helped push deliveries of piston-powered aircraft to 1,324 in 2019 from their recent low of 889 in 2010.

"The flight-training industry in America for sure has been on a growth path," says Robert Rockmaker, president and CEO of the Flight School Association of North America (FSANA). "The 'zero to hero' career training pathway has been serious in its growth over the past several years."

When COVID-19 struck, a majority of U.S. flight schools shut their doors. But not all of them. "Approximately 35-40% of the flight schools stayed open," Rockmaker tells Aviation Week. "They were operating at much lower levels, but they were operating."

There was confusion initially over whether flight schools were considered essential infrastructure, until the Cybersecurity and Infrastructure Security Agency (CISA) specifically listed flight instructors as essential workers supporting air transportation.

"Some schools reopened as they became educated and re-

alized they might be called on as part of the emergency infrastructure for the system," Rockmaker says. Some state and local governments tried to shut down schools, but reversed their decisions when faced with the CISA guidance, he adds.

By mid-May, more schools were reopening. "By the end of June, I suspect that just about every flight school is going to be back operating," Rockmaker says. But there will be casualties. "There are some flight schools that are not going to make it."

The industry last contracted after the terror attacks of Sept. 11, 2001, and the repercussions of the terrorists having trained at U.S. flight schools. "Prior to the terror attacks, we had about 2,400 flight schools in the U.S.," he says. "After the terror attacks and things settled down, we ended up with 1,600 before COVID."

"After COVID, I'm estimating we're going to lose anywhere from 25-30 on the low side to [as many as] 100-125. There will also be new schools starting up, but I suspect there will be a net loss over the next 6-12 months. It's never okay to see somebody close, but it's about quality, not quantity."

Rockmaker thinks demand for training aircraft will remain steady because the average age of the U.S. fleet is over 25 years. "We are seeing more schools thinking about their aircraft fleets: what they need versus what they can justify," he says, and FSANA is working to bring cheaper light sport aircraft to the training market.

Maintenance training has also been affected, although in the U.S. the FAA moved quickly to allow flexibility to temporarily provide content online, says Crystal Maguire, executive director of the Aviation Technician Education Council (ATEC).

Only a handful of Part 147 maintenance-technician schools provided online training before the crisis. Now 75% of ATEC's 181 members have approval for online delivery, although content is restricted. Completing hands-on lab work required for certification is still an issue.

But the remainder of ATEC's member schools have suspended training, which will affect output, Maguire said on a Helicopter Association International (HAI) webinar in mid-May. A survey of members concluded that output of trained mechanics will decrease 25% this year, while enrollment is expected to drop 28%.

Even as the industry restarts, demand for commercial training is expected to decrease. While U.S. airline pilot groups still hope furloughs can be minimized, "there's not a need for a lot of pilots right now," acknowledges Rockmaker. "To come back to where it was before COVID, it could take 8-12 months at the earliest. It could go out as far as 24-36 months."

Continued restrictions on international travel are one reason a recovery may take longer. Up until the pandemic hit, more than 50% of flight students in the U.S. were from overseas. As training resumes and schools follow guidelines for temperature screening of staff and customers, the issue arises of what happens if a foreign student tests positive. "I don't have that answer," Rockmaker admits.

HELICOPTERS

The commercial helicopter industry was locked in a downturn even before the COVID-19 crisis. Deliveries fell again in 2019, to a low of 640 turbine helicopters from the high of 1,111 in 2013. Deliveries of piston helicopters, which had

been boosted by demand for training, also declined in 2019.

The reason for the market's stubborn stagnation was the price of oil, which fell from highs beyond \$100 a barrel in 2012-14 to just above \$60 by January 2020 because of overproduction. Energy companies cut back on exploration and production, reducing demand for air transportation and idling helicopter fleets.

Oil prices continued to fall, and in April producers agreed to a record cut in global output. But the pandemic lockdown destroyed demand, and prices fell to negative numbers for the first time in history in April. The International Energy Agency is forecasting global energy demand will fall 6% in 2020, seven times the decline after the 2009 financial crisis.



AIRBUS

Manufacturers worry about sales of medium and heavy helicopters when oil falls below \$50 a barrel, aviation consultants JSfirm told an April 23 HAI webinar. The U.S. Energy Information Administration forecasts the benchmark Brent crude price will average \$34 a barrel in 2020, down from \$64 in 2019, and recover to \$48 in 2021.

Offshore operator CHC Helicopter expects a 20-30% reduction in flight hours this year. "And that's going to have a material impact, not only on ourselves but on the whole supply chain," President and CEO David Balevic told a Vertical Flight Society (VFS) webinar on May 28. "Everything is going to change as the supply chain starts to contract and focus on its resilience and its liquidity."

In addition to halting exploration activity because of falling prices, energy companies reduced manning on offshore platforms as COVID-19 hit to keep crews safe. This scaling down is not sustainable, and transport flights are resuming, Tony Cramp, Shell vice president for aviation, told the webinar. But the pandemic keeps spreading. "Brazil is the next big concern for us. It's almost a tinderbox," Balevic said.

The immediate impact on manufacturers came from travel restrictions. Leonardo lost seven deliveries in the first quarter, mainly AW139s, because customers did not want to travel to pandemic-stricken northern Italy to pick up their machines, CEO Alessandro Profumo told analysts on May 7. Bell delivered 15 commercial helicopters in the first quarter, down from 30 a year earlier, because of customers' inability to accept aircraft.

Leonardo is shifting to "smart deliveries," digitally transferring all data to customers from final company testing of the aircraft. "That makes them comfortable that the ma-

chine is in good shape, as if their own pilots had tested it," Profumo said. But Leonardo does not expect any significant speed-up in deliveries into June.

Bell had not seen any cancellations, Donnelly, CEO of Bell's parent Textron, told analysts on April 30. Parapublic and international sales "are largely holding up" and this diversified set of markets is expected to be more resilient, he said. But private and corporate sales are likely to be "a little softer."

Airbus expects civil and parapublic helicopter demand to remain soft in 2020, "particularly in oil and gas, mainly due to very low oil prices," CEO Guillaume Faury told analysts on April 29. But Airbus, like Bell and Leonardo, is being cushioned by continued demand for military helicopters.

Profumo said Leonardo had not seen any major effect from record-low oil prices, but that is largely because it is delivering on an order for 21 AW139s from Saudi Aramco. Bell is less exposed. "We don't do a lot of the big offshore stuff. It's the Gulf. It's nearshore operations, which I think are more likely to hang in there," said Donnelly.

Helicopters were quickly modified and pressed into service transporting COVID-19 patients to intensive care units.

"I think it's safe to say you're not going to see a whole lot of deepwater, big-dollar investments to get at some of the more expensive oil," Donnelly said. But energy companies put limits on the age of aircraft used, which could backstop demand. "People are still producing, and they are still going to have to run their operations," he said.

THE FUTURE

General aviation entered the new decade with several innovations in prospect, ranging from autonomy and electrification to operating delivery drones and air taxis. Many of these advances were being led by startups funded by venture capital. But the COVID-19 pandemic has slowed dealmaking and the booming fundraising market could experience its first serious decline since the 2009 economic crisis, says private equity analyst Pitchbook.

Results so far have been mixed. Deals continue to be announced, but most were closed before COVID-19 hit. Perhaps the biggest impact has been the interruption of flight testing, with developers of technologies ranging from advanced flight controls and unmanned cargo aircraft to electric propulsion unable to fly because of the lockdown.

But many of the new technologies are software-intensive, and several startups report they have been able to continue with software development and simulation testing—work that may speed progress once flying can resume. Skyryse and Xwing, startups developing advanced control and autonomous flight systems for retrofit to general-aviation aircraft and helicopters, say they have been able to maintain good progress in certification discussions with the FAA via web conferencing.

The pandemic may actually have accelerated the market for delivery drones, with several companies stepping up service in response to the COVID-19 crisis. In April, Alphabet subsidiary Wing said the outbreak had driven a significant increase in use of its drone delivery service in Virginia. Also in April, Flytrex began delivering groceries from a Walmart to backyards in Grand Forks, North Dakota.

In May, UPS Flight Forward (UPSFF) began delivering prescription medicines from a pharmacy to a retirement

community in Florida using Matternet drones. The North Carolina Department of Transportation also launched three projects to use drones to aid COVID-19 relief efforts: Zipline delivering protective equipment and medical supplies to Novant Health campuses in Charlotte; UPSFF flying equipment and medicine for a hospital in Winston-Salem; and Flytrex carrying food to homes in Holly Springs.

These expanded operations are being conducted under the FAA's unmanned aircraft Integration Pilot Program. This includes package delivery by drone through Part 135 air carrier certification. So far the FAA has awarded Part 135 certificates for drone operations to Wing and UPSFF, with seven more in the works, the agency says. COVID-19 relief drone flights are also being tested in the UK and elsewhere.

Another sector that was surging before COVID-19 hit was urban air mobility (UAM). Uber has yet to alter its plans to conduct test flights of an experimental electric vertical-takeoff-and-landing (eVTOL) air taxi over a U.S. city this year, and begin commercial service in 2023, despite announcing cuts after its ride-hailing business took a massive hit because of the pandemic. But most observers expect a delay.

In a survey of the nascent eVTOL market, conducted by VFS, more than half of respondents said COVID-19 had not affected their ability to meet near-term milestones. "It's too small a sample size to draw any real conclusions, but it indicates to us that these companies at least are managing the crisis," says VFS Executive Director Mike Hirschberg.



GLOBAL JET

The business aviation industry is looking for signs that passenger health concerns could boost private flying.

Startups continue to emerge, but more than a quarter of the respondents to VFS' survey voiced significant concern about the long-term impact of COVID-19 because of changes to underlying business assumptions. These include the possibility that many people in previously congested cities who have been able to work from home will continue to do so even after the pandemic ends. 🗳️

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How To Keep Sustainable Aviation Fuel Sustainable?

What is the maximum quantity of sustainable aviation fuel, as a percentage of pre-COVID-19 worldwide fleet consumption, that could be created per year without adversely affecting food production or causing a negative environmental impact such as deforestation?

Aviation Week France Bureau Chief Thierry Dubois responds: How much sustainable fuel will aviation need? The International Civil Aviation

materials manufacturer Saint-Gobain) and economists (such as Nicholas Stern).

But what about demand from other sectors? Aviation should take priority, according to the ETC. As a matter of fact, fossil liquid fuels—and their bio-fuel equivalents—are particularly well-suited to aviation because of their energy density. “Aviation is almost the only sector of the economy where . . . there appears to be no feasible alternative to a bio-based route to achieve net-zero carbon emissions,”

“There are exciting long-term opportunities with synthetic fuels such as ‘power to liquid,’” adds a spokesman for the Air Transport Action Group (ATAG), a lobbying group in commercial aviation. The process uses sunlight as the power source to convert CO₂ from the air and water into jet fuel. Challenges are the low power density of sunlight and the stability—as opposed to reactivity—of water and CO₂.

ATAG sees sustainable aviation fuel as part of the solution, along with aircraft technology and operational improvements, for the industry to meet its goal of halving CO₂ emissions by 2050 from 2005 levels. But a tight definition of what constitutes a “sustainable biofuel” will have to be embedded



Organization estimates that about 600 million metric tons of jet fuel will be necessary to cover all aviation needs in 2050. This could require up to 45 exajoules (EJ, a unit of energy) of biomass input to biofuel production, given the relatively low efficiency of the transformation process.

A sustainable biomass supply of 70 EJ could be produced each year, “possibly going up to 100 EJ, thanks to tightly regulated reforestation efforts,” the Energy Transitions Commission (ETC) suggested in a November 2018 report. So all aviation demand in 2050 could be met by sustainable biofuel production, according to the ETC, which is a lobbying group representing energy producers (such as Shell), energy users (such as mate-

the ETC report says. Batteries and hydrogen are ill-suited because of their low energy density.

The group sees a strong case for treating aviation as the priority sector for the predictably limited supply of sustainable biofuel. However, the industry cannot rely on developments in the road transport sector to drive biofuel development and production volume—the onus is on aviation to create and foster a viable industry. A key factor to sustainability is keeping the use of purpose-grown plants to a minimum, as they would compete with food production. Fuel should be created primarily from waste streams, says the ETC. A challenge then is to collect municipal, agricultural or forestry waste.

in any policy aiming at increasing bio-fuel adoption in aviation. The nongovernmental environmental organization Greenpeace insists no crop-based biofuel can be considered sustainable. “Advanced biofuels without a negative impact on the environment or the right to food do not exist on a large scale,” says a Greenpeace spokesperson. “Clean fuels are an argument the industry has been increasingly using, but they are a pipe dream.” ☒

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Aerospace Calendar

To submit Aerospace Calendar Listings

email: aero.calendar@aviationweek.com

June 15-19—American Institute of Aeronautics and Astronautics (AIAA) Aviation Forum. Virtual event. Reno, Nevada. See aiaa.org/aviation

June 18-Aug. 20—RTCA Plenary Sessions/Committee Meetings. Virtual or various locations (check website). See rtca.org/content/upcoming-committee-meetings

June 25—Space Tourism Conference. The Proud Bird. Los Angeles. See spacetourismconf.com

July 20-21—DoD Hypersonic Capabilities Symposium. Mary M. Gates Learning Center. Alexandria, Virginia. See hypersonics.dsigroup.org

Aug. 1-6—Small Satellite Conference (SmallSat 2020): Space Mission Architectures. Virtual event. See smallsat.org

Aug. 4-6—Space and Missile Defense Symposium. Von Braun Center. Huntsville, Alabama. See smdsymposium.org

Aug. 9-13—AAS/AIAA Astrodynamics Specialist Conference. Virtual event. See space-flight.org/docs/2020_summer/2020_summer.html

Aug. 24-26—AIAA Propulsion and Energy Forum and Exposition. Hyatt Regency New Orleans. New Orleans. See aiaa.org/propulsionenergy

Aug. 31-Sept. 1—2020 Humans to Mars Summit (H2M). National Academy of Sciences Building. Washington. See exploremars.org/summit

Sept. 3-4—Military Space Situational Awareness Conference 2020. Holiday Inn Kensington Forum. London. See smi-online.co.uk/defence/uk/milspace

Aviation Week Network Events

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Aug. 5-6—CAPA Australia Pacific Aviation Summit 2020. Adelaide, Australia.

Aug. 11-13—Urban Air Mobility Virtual. Virtual event.

Aug. 25-26—Aerospace Manufacturing Conference. Charleston, South Carolina.

Sept. 1-3—MRO Americas. Dallas.

Sept. 2-3—Military Aviation Logistics & Maintenance Symposium (MALMS). Dallas.

Sept. 14-16—Commercial Aviation Industry Suppliers Conference-Europe. Toulouse, France.

Sept. 16-17—Aero-Engines Europe. Virtual event.

Sept. 22-24—MRO Asia-Pacific. Singapore.

Sept. 23-24—Aero-Engines Asia-Pacific. Singapore.

Oct. 8-10—Routes Asia 2020. Chiang Mai, Thailand.

Oct. 15-16—CAPA Americas Aviation & LCCs Summit. San Juan, Puerto Rico.

Oct. 19—Aviation Week Laureates Awards. McLean, Virginia.

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FROM THE EDITOR

Life After COVID-19

Three months ago, I was shaking lots of hands and navigating my way through dense crowds at our SpeedNews suppliers conference in Beverly Hills when I received an ominous warning from a friend who is a doctor at the U.S. Centers for Disease Control. “You may want to head home,” she texted. A week later, our offices were closed, our events were being postponed, and for the first time ever, our entire staff was working from their homes.

The COVID-19 crisis descended on Europe and North America with a suddenness and ferocity few saw coming, sending cities into lockdown, bringing airline travel to a virtual halt and choking off demand for aircraft and services. It was a gut punch to a commercial aircraft industry that had seen almost uninterrupted prosperity for 15 years. It also created an insatiable demand for information.

At Aviation Week, our editorial team has been working overtime to provide readers with information and answers about this unprecedented crisis. With this issue, we present the first article in a new feature, Flight Paths Forward (see page 48). Researched and written by Executive Editor Graham Warwick, it provides a detailed examination of the future of business and general aviation and lays out three scenarios—optimistic, neutral and pessimistic—into which the sector could emerge from the coronavirus crisis. In the coming months, our editors will be providing you with similar outlooks for key areas in the air transport, defense, MRO and space industries.

Flight Paths Forward is just the latest of several new features we have created to help our readers make sense of these crazy times. Others include:

- A new free, interactive webinar series that allows our readers to hear from and ask questions of industry CEOs, analysts and Aviation Week Network editors and data analysts. The webinars have proven immensely popular, attracting 75,000 registered viewers since mid-March. Go to [AviationWeek.com/webinar](https://www.aviationweek.com/webinar) to find out which webinars are coming next and view recordings of recent ones.

- Ask the Editors, a daily online feature where our editors answer questions posed by subscribers. You

can find it at: [AviationWeek.com/asktheeditors](https://www.aviationweek.com/asktheeditors)

- Two new analytical columns for premium subscribers to the Aviation Week Intelligence Network (AWIN). In *The Daily Memo*, Executive Editor Jens Flottau and his team provide insightful looks at the latest trends in the air transport industry, including deep dives into clues offered by AWIN fleet data. And *The Weekly Debrief* offers inside analysis on military trends and technologies from Defense Editor Steve Trimble and his colleagues.

Meanwhile, our Check 6 podcast is still going strong, receiving more than 60,000 downloads in May and ending the month on a strong note when SpaceX’s Elon Musk and Gwynne Shotwell joined Space Editor Irene Klotz to preview the launch of two astronauts to the International Space Station. See [AviationWeek.com/Check6](https://www.aviationweek.com/Check6)

Our editors also will continue to report regularly, online and in print, on pivotal technology developments in fields such as hypersonics, electric propulsion, autonomy and additive manufacturing (see page 40). Our series on efforts to make the aviation industry more sustainable also goes on, highlighting paths toward a greener future as companies recover.

Looking ahead, the town of Farnborough may be quiet in July, but we won’t be. To coincide with what would have been the aviation industry’s biggest air show of 2020, we are planning to roll out a massive package of content online and in print: interviews with leading aerospace CEOs, updates on next-generation fighter programs and European defense cooperation, webinars, “Tech Talk” podcasts and in-depth features on the future of key aerospace and defense OEMs and suppliers.

The aviation sector is beginning to claw its way out of this crisis. There is a long recovery ahead, and the coming months will be painful. But our global team of more than two dozen reporters will be here every step of the way to help you understand what’s coming and the ways in which COVID-19 will reshape our industry for years to come. ✎

—Joe Anselmo, Editor-In-Chief



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71st IAC2020

The CyberSpace Edition

71st International Astronautical Congress

– The CyberSpace Edition

12-14 October 2020

The International Astronautical Federation (IAF) is pleased to announce that the IAC 2020 will be hosted in a virtual format. The **71st International Astronautical Congress – The CyberSpace Edition** will take place in your homes and offices around the world on **12 – 14 October 2020** without registration fee, **free of charge** for a global community.

In this challenging period, the IAF wants to make sure that everybody is safe but we also want to ensure that our community stays engaged and connected. The Federation has been supporting the space community for more than 70 years, and we will continue to do so also now.

Despite the challenges due to the COVID-19 pandemic, the IAF is confident that humanity can emerge from this crisis stronger than before and that together we will continue to discover innovative and creative ideas on how to shape a global society with the help of space technologies for a bright future.

Visit www.iafastro.org to find out more and be part of the conversation on **#CYBERSPACEIAC2020**

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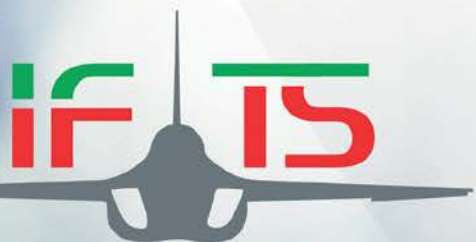


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